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The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

Beverage for Science

It was recently suggested in these columns that science needed its Beveridge Plan for demobilisation and reconstruction if the full benefits of scientific knowledge were to be made available in post-war Britain. Such a plan has now been produced in the form of the report of the Parliamentary and Scientific Committee on "Scientific Research and the Universities in Post-War Britain." It is a document of the first importance, for it sets out in authoritative form the general requirements of British science. At worst it will, like the Beveridge Plan, constitute a statement which cannot be ignored and which will compel at least a measure of progress: at best, it will, like the Beveridge Plan if it is implemented fully, secure the minimum requirements which will enable us to evade certain disaster.

The comparison with Beveridge is an important one, for both plans deal with provisions which are obvious. The one lays down the conditions, obvious for all to see, for social security in the future. The Parliamentary and Scientific Committee's Report lays down the conditions, obvious to most scientists, which must be satisfied if the reconstructed Britain is to have its essential firm basis of technical and scientific knowledge. There the similarity ends however, for while the Beveridge Plan's merits were at once obvious to all, the scientific plan's merits are obvious only to scientists; and it does not follow that they will seem at all necessary to the majority of the lay public, or to the membership of the Houses of Parliament. There will, therefore, be all the greater temptation to whittle down the provisions of this plan (if it should in the end find its way into the House as a subject for debate) in the belief that money saved on such objects is true economy. To the scientist the fallacy of such a view is obvious. He knows very well that scientific measures cannot be whittled down without rendering them useless. A powerful anti-aircraft weapon can wipe the enemy out of the skies. Its design and construction are matters of scientific and military advice, and that advice will be taken because it is realised that a weapon half as powerful is not an economy but a hopeless failure. In the same way, if the protagonists of economy are allowed to pare away the provisions of this report which are a matter of scientific and economic advice, the whole project will be rendered futile, and we shall find ourselves in the position of men who are trying to save the ship by baling it out with tea-spoons in order to avoid the purchase of a pump.

The solution, as in the case of the Beveridge Plan, is therefore the widest possible publicity and explanation for the provisions of the report. This is a task which must be commenced at once, since the provisions of this document have been made public at a much earlier stage than those of its counterpart, which first appeared as a White Paper.

The report itself realises the necessity for self-justification in lay eyes, and begins its exposition by pointing out the urgent necessity for much increased scientific facilities if this country is to do no more than retain its standard of living and its status among the comity of nations. It rightly compares the expenditure of certainly not more than £7,000,000 per annum in this country with the corresponding figure of £70,000,000 in the U.S.A., and it points out that the maintenance of much higher levels of research and scientific expenditure both there and in the U.S.S.R. over a period of years have produced a lead which must increase steadily and cumulatively unless measures are taken to put our own house—or rather laboratory—in order. The comparison of expenditure on universities, vital as the sources of our human scientific assets, is equally unfavourable to this country and an equal source of danger to our future.

The report stresses the importance of fundamental research, remarking, "We are beginning to live too much either on past endowments or on private benefactions from abroad", and has a few words to say on its importance not only in universities but also for government and industrial research. This matter of the necessity of fundamental research is one which cannot be too widely or publicly exposed. We must face the fact that the general public as a whole does not realise its importance, and tends to regard it with the not very serious approval

accorded to an activity which is somewhat mysterious and esoteric, and undoubtedly difficult, but nevertheless of little significance for everyday life.

In the section in which it urges the extension of agricultural and medical research by the expansion of the two research Councils, a further important point is raised. It is that while knowledge of scientific agriculture has been greatly advanced by the efforts of British scientists, we have "failed until recently to be active enough in bringing the results of such research on to our farms and into our practice of husbandry." This implies therefore that in addition to providing the means for actually producing scientific advance, we shall later on have to tackle the problem of getting those advances into general use.

Speaking of industry the report notes the increased support and recognition accorded to scientific research, and cites examples of industries, such as the electrical, radio, coal, which have made public acknowledgement of the need for greatly increased research. The list is a lengthy one, and one gains the impression that scientific research has become fashionable under the stress of war. It is not perhaps excessively cynical to remark that considerable efforts may be necessary if this is to prove more permanent than a passing fashion. To-day, there are no obstacles to the most rapid technical development in industry. In the future science may again become the first victim of an economy axe, when it might be the very means of avoiding restrictive economies altogether.

Part I ends with a short discussion of university research, pointing out that the universities have a dual function as the source of scientific workers and as centres of fundamental research, and urging increased finance adequate to avoid the existing humiliating situation whereby heads of departments often have to go cap in hand to a series of possible benefactors before they can initiate research even of the highest importance.

Part II deals with scientific personnel, and urges in respect of those scientists we already possess, a high priority of demobilisation from the services or from war-time employment. For some, a course of training appropriate to the industry into which they are going will be necessary; for others, such as those trained under the State Bursar schemes, a period of fundamental training at the universities will be a necessary prelude. The Committee is especially urgent in asking for the provision of facilities for these changes to be made in a thoroughly systematic way instead of leaving them to the disastrous hazards of chance.

For the training of new personnel increases both in numbers and financial and other facilities are urged. It will come as a shock to many to learn that just before the war there were only some 13,000 science students (excluding medical and agricultural students) in our universities, many of them recruited by methods which placed a premium on personal wealth or on the ability to acquire a temporary expertise at the expanse of all-round intellectual development. The retention of the State Bursar scheme extended to meet peace-time needs is a welcome recommendation which will overcome many of these difficulties. The extension of existing universities, the upgrading of existing institutions, and perhaps the foundation of new universities are necessary corollaries of a possible ultimate doubling of the number of science students.

After graduation the young research worker must be adequately supported and encouraged, and reform is urged in the existing system of grants by the Department of Scientific and Industrial Research, which are both inadequate in amount and in numbers. Other equally necessary reforms are the provision of more facilities for post-doctorate research and for refresher courses bringing the Universities and Government service into closer relation with industry. Obviously the teaching staffs of the Universities have an essential part to play here, and the Report has some caustic comments to make on the relatively poor salaries paid to young dons, which cannot but have the effect of diverting part of their energies to lucrative sidelines at their most productive period.

Other topics discussed are the encouragement of young workers in industry to become better trained and the general provision of adequate facilities for technical education. Here the extension of the proposed pre-war programme of £12,000,000 is regarded as urgent, together with the possible transformation of some of the existing institutions into institutes of technology on the American pattern, with more full-time work and chairs, including the urgently needed ones of radio engineering and aeronautics.

It is the financial provisions of the Report which will come in for the strongest attack. They include £5,000,000 per annum increase for the universities, and a capital sum of £10,000,000 for university development over five years: more for technical education, new institutes, and better finance for the Department of Scientific and Industrial Research. Perhaps it will cost us £20,000,000 or even £50,000,000 per annum to implement these proposals, but what will it cost us not to implement them? Here is a chance of making Britain a great nation once more for less than £1 per head per annum. As in the case of the Beveridge Plan, the cost seems large but is little enough by comparison with what may be gained. As Professor A. V. Hill has said, "Let us aim high in these matters from the start.... The final result may then be the five- to tenfold improvement and increase of scientific and technical education which the technical needs of our future will require.

Making Diamonds

MANY readers will be familiar with H. G. Wells's story of the man who made diamonds by subjecting carbon to high temperature and pressure, and of his subsequent difficulties in proving his honesty when he tried to sell the product of his labours.

The true stories of those who have attempted to manufacture artificial stones by converting carbon into its crystalline form are almost as fascinating, although the results have never been sufficiently successful to embarrass the experimenters. At first sight the problem seems simple enough. Diamonds, valued as gems and of immense importance in industry for drills, dies and abrasives, are nothing more than a crystalline form of the carbon familiar enough as graphite, lamp-black, or sugar charcoal. To convert diamonds into these valueless forms is easy enough, but a consideration of the energy content and specific gravity of the two forms of carbon shows that the reverse transition can only be expected to take place

at high temperatures and under enormous pressure. In fact, it is to the occurrence of such conditions in the cooling crust of the earth that we must look for an explanation of the formation of natural diamonds.

Several workers, using various devices to secure simultaneous high pressures and temperatures, have claimed success in the manufacture of diamonds, but in every case the yields have been so poor and the crystals so minute that it was impossible by contemporary methods to be certain whether they were diamonds or not.

J. B. Hannay, working at Glasgow in the latter half of last century, filled cast-iron tubes with a mixture of bone-oil, paraffin, and metallic lithium, sealed the tubes by welding, and heated them to redness. The action of the lithium liberated carbon from the paraffin, and a very high pressure was produced, often sufficient to shatter the inch-thick tubes and to cause great damage. However, Hannay persevered, and eventually, as the result of three separate experiments, he obtained from the charred masses left in the tubes a total of twelve tiny crystals which he believed to be diamonds. An examination of the physical properties of the crystals by Nevil Story-Maskelyne, who found them identical with those of natural diamonds, confirmed this opinion, and chemical analyses lent further support by showing them to contain almost 98% of carbon. The crystals were eventually sent to the British Museum, where they have remained ever since.

In spite of this confirmatory evidence Hannay's results were received with some scepticism, which was increased as the result of the work of Sir Charles Parsons, who attempted to repeat Hannay's work. He is said to have spent more than £20,000 in his researches, and in 1920 he published an account of them describing a variety of modifications of the method. From certain of his experiments he obtained small crystals which he believed at the time to be diamonds, but Lord Rayleigh, in a recent letter to *Nature*, asserted that at the end of his life Parsons entertained doubts as to the nature of his crystals. Unfortunately they have since been lost and the problem remains a mystery.

Moisson, another prominent worker in this field, also claimed to have made diamonds. His method was to pour molten iron mixed with pure black carbon into cold water, when the contraction of the outer layers on solidification resulted in the exertion of great pressure on the still molten interior. After removing the excess iron with acid crystals, Moisson obtained in several of the experiments, which were apparently diamonds and which analysis showed to be almost pure carbon. In later years however, doubt was cast on Moisson's analyses, and it was suggested that his crystals were really carborundum (carbon silicide). Unfortunately Moisson's crystals too have been lost, and are not available for examination by modern methods.

After the publication of Parsons' results very little further work seems to have been done, but in 1928 a critical review of the subject in *Nature* held that up to that time diamonds had not been prepared artificially and that the crystals which had been made were merely carborundum or similar substances.

However, in the last few months Hannay's crystals from the British Museum have been re-examined by Bannister and Lonsdale using a refined X-ray method of crystal analysis, and it had been shown that eleven of the crystals are in fact diamonds. The twelfth, however, is not a diamond, and its nature has yet to be determined. Even without the lost crystals of Parsons and Moisson, the manufacture of artificial diamonds must therefore be regarded as an accomplished fact.

However, the yields are so small that their manufacture as a commercial proposition is quite out of the question; but it is interesting to speculate on the consequences which might follow if it eventually became possible to manufacture diamonds comparable in quality and size with the artificial rubies and amethysts produced for industrial and other purposes in France and Russia.

An Irish Scientist

THE Government of Eire have issued a series of stamps commemorating the invention of his theory of quaternions by Sir William Rowan Hamilton, the Irish scientist and mathematician. This mathematical theory was announced to the Royal Irish Academy on November 13th, 1843, the final stages in the process of deduction having come to Hamilton during a walk along the banks of the Royal Canal in Dublin. This sudden culmination of a long process of

Brown

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directed thought at a moment in which all the conflicting mental constructs are seen to fit together in a single ordered pattern is an excellent example of the methods of thought followed by theoretical scientists, and fortunately the exact circumstances of this particular case have been recorded for us in Hamilton's letter to his son describing the experience. As Henri Poincaré, the French mathematician who experienced a similar moment of insight while boarding a bus, conjectured, these flashes of inspiration are not undirected and uncontrollable visions. They are the result of a long period of preoccupation in which the subconscious mind plays a very large part, the resulting orderly construct coming to the conscious mind often with a suddenness which may suggest, even to the thinker himself, the intervention of some outside influence.

Whatever the correct view of this process may be, it is undoubtedly the case that Hamilton's discovery has exercised a considerable influence on the course of mathematical development since his day. At the beginning of the nineteenth century mathematicians were realising that their discussions, especially of physical problems, could not without serious restriction be made solely in terms of ordinary numbers, and they had begun to use not single numbers but pairs of numbers, regarded as of different kinds. These so-called "complex numbers" are in very extensive use to-day in all branches of mathematics, in physics, and in engineering. Hamilton's contribution consisted in the development of "quartets" of numbers which could be used to describe many physical and geometrical entities. It cannot be said that Hamilton's work was received with universal acclamation, partly

perhaps because of the somewhat obscure style of his papers, and some workers—for examplee Lord Kelvin (Sir William Thompson)—refused to have anything to do with them. The latter wrote a standard text-book in collaboration with P. G. Tait, who was a devotee of quaternions and who had familiarised himself with their use in a long correspondence with Hamilton. Kelvin refused to allow the introduction of quaternions unless it could be shown that they were essential to the exposition, and delivered himself of various caustic comments on them on a number of occasions. However, James Clerk Maxwell, the mathematical physicist who predicted the existence of "wireless" waves, was much more sympathetic, and wrote one of his poems to the honour of Tait and his use of quaternions.

On the other hand the development of the idea of using groups of numbers to which Hamilton's work gave a great impetus has now become universal, although the mathematical methods used are not those developed by Hamilton. Such methods are of immense value in many branches of physics and mathematics including mechanics and the theories of atomic structure and of relativity.

The fame of Hamilton in the eyes of mathematicians rests far more securely on his contributions in other fields. It may seem somewhat childish to set store merely on the *formal* arrangement of mathematics, but it is a fact that a bad system of notation and a bad formulation of a problem can multiply the difficulties of a mathematical or physical investigation to a prohibitive degree. Hamilton's contribution was that he showed that the laws of mechanics and of many other fields could be formulated in particularly simple and general ways which rendered their solution possible. The tools of investigation which he made available have been of incalculable value, and have resulted in advances comparable perhaps to those which the invention of the internal combustion engine made possible in other fields. His principle of "Least Action" is a synthesis of the description of the behaviour of natural phenomena of incredible power. The so-called Hamiltonian equations and the mathematical expression known as the Hamiltonian have opened up new fields of investigation in all branches of science, including the most modern developments of the theory of atomic phenomena and the motion of the moon and planets. It is slightly ironic that the contribution to science by which Hamilton himself set the greatest store should have been the one which, at any rate in the form in which he propounded it, had a slighter influence than his other work.

Hamilton as a man had a remarkable career beginning with the fact of his birth in Dublin exactly at midnight on August 3rd, 1805. He went on to study languages under the tuition of his uncle becoming a scholar in Latin, Greek, Hebrew, Italian, French, Arabic and Sanskrit by the age of 10, and by 14 he had added several Eastern languages and dialects, including Persian, in which language he composed a welcome to the new Persian ambassador.

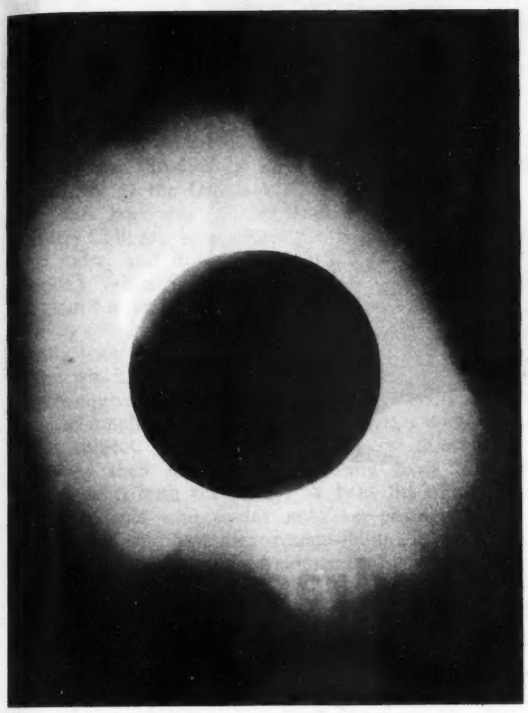
Fortunately at the age of 12 he met Zerah Colbourn, the famous American mathematical prodigy who was a year older than himself, and this meeting turned Hamilton's interests towards mathematics. His studies were conducted almost entirely on his own, with the assistance of the linguistic uncle, and by the age of 17 when he entered Trinity College, Dublin, he had already accomplished some original scientific work. His college career was tremendously brilliant, and he obtained the highest honours both in mathematics and classics. It ended by his election at the age of 22 to the professorship of astronomy carrying with it the directorship of the Dunsink Observatory. A year later he published his work on *A Theory of Systems of Rays*, which included for the case of optics the statement of the fundamental Principle of Least Action.

A few years later his prediction of a special optical effect occurring in certain types of crystal was verified. This prediction has been compared in its theoretical background and unexpectedness to the striking predictions which secured general acceptance of the theory of relativity. Until his death in 1865 the remainder of his working life was to a considerable extent occupied with his work on the algebra of quaternions and their applications, and in his scientific correspondence with men such as Tait. In the latter part of his life he became almost a recluse, neglecting his meals and health in the construction of the quaternion theory. There is indeed a strange flavour of tragedy about the life of this man of outstanding intellect who blossomed so young, was a friend of poets such as Wordsworth, Southey and Coleridge, was a professor at 22, and a knight at 30, but who ended his days worn out with work and neglect of his own health in the service of a powerful means of mathematical and physical investigation so soon to be superseded by methods more general in character.

The Solar Corona

IT is perhaps verging on the astrological to comment on the way in which important solar discoveries have been hampered by wars. The last war ended only just in time to permit the undertaking of the eclipse expeditions to observe the bending of light rays in the gravitational field of the sun which constituted one of the three crucial tests of Einstein's theory of relativity. An important discovery which has been partially eclipsed in the present war is the identification of the origin of the spectrum lines of the solar corona.

The corona is the name given to the irregular and faintly luminous cloud which surrounds the sun and which extends outwards for something of the order of a million miles. Its total brightness is comparable with that of the full moon, and until recently it had never been observed except during eclipses of the sun, when the overpowering light from the sun itself was temporarily cut off. The nature of the matter composing the corona, its physical condition, the mechanism by which it maintained its great extension were all unexplained. Even more difficult of explanation was the fact that the structure of the corona varied in sympathy with the activity of the sun itself, appearing as a fairly uniformly distributed cloud of pearly white when sunspots are most numerous, and being embellished with a series of fine plumes or streamers at sunspot minimum. A valuable contribution to our knowledge of coronal structure was made as the result of the work of the Russian expeditions which observed the eclipse of 1936. Several expeditions along the 7200 km. of track which passed across Soviet territory—and which therefore saw the eclipse at different times—confirmed the view that the corona rotated with the sun, and that its arches appeared to originate from disturbed regions on the sun's surface.



Courtesy of the Astronomer Royal

The solar corona at the eclipse of May 29th, 1919, at which the expedition from the Royal Observatory, Greenwich, verified one of the predictions of Einstein's theory of relativity. At this time the sunspot cycle of eleven years was one year past its maximum.

Perhaps the greatest advance of all was due to the work of Bernhard Lyot, who established an observatory high in the clear air of the Pyrenees and, with simple equipment of superb quality was able to see and photograph the corona in full sunlight simply by covering the sun's disc with a circular screen of the correct size. Simple as this method sounds, it achieved success only after years of effort, and astronomers all over the world acclaimed his work and applauded the award to him of the Gold Medal of the Royal Astronomical Society in 1939.

But the biggest mystery of all was the coronal spectrum, which until Lyot's work had only been recorded throughout the history of astronomy for a total of a few minutes during solar eclipses. Luminous sources of hot gas reveal their chemical constitution by emitting radiation in certain definite colours which are known to originate in definite chemical elements. From these known "trade marks" chemical, elements can be recognised, and chemical analysis can be conducted in this way even of objects far out in the depths of space. However, here (astronomically speaking practically on our own front doorstep) was a cloud of tenuous gas emitting lines which had never been satisfactorily identified, and whose identification might lead to enormous advances in our fundamental understanding of the behaviour of gases at very low pressures and very high temperatures.

At one time, encouraged by the example of the element Helium, which was first discovered in the sun by its spectrum and only later found on earth, a new element "Coronium" was suggested as responsible. However, this suggestion lost favour, and in the less serious columns of one of our astronomical journals a writer was moved a few years ago to declare that "Coronium is Bolonium".

In recent years new clues were discovered. In the spectra of an exploding star or Nova were found some of the coronal lines, a fact which suggested that we must in the corona be dealing with matter in a quite extraordinary state of heat and light stimulation or "excitation". Now at last the mystery has been solved by the Swedish physicist B. Edlén, knowledge of whose work has only with difficulty been circulated through the scientific world which still manages to retain some of its international character in spite of war. Edlén has identified the lines as due to Iron, Nickel, Calcium and Argon, all familiar enough in spectroscopic and chemical work. The difficulty arises from the quite extraordinary state in which these substances exist. It is easy enough to separate electrons from atoms, leaving them temporarily with one or two electrons short, and producing what are called ions. The unfamiliarity of these familiar elements in the corona is due to the fact that the iron atoms have had nine, ten, twelve, thirteen or even fourteen of their electrons torn away, the nickel atoms as many as fifteen, the calcium fourteen and the argon thirteen. It is no wonder that we no longer recognise old friends under these extraordinary conditions. To the spectroscopist the phenomena and their causes are as bizarre and as difficult of explanation as the sudden apparition of a bishop in his underwear.

There can be no doubt that the possibilities for future solar research are almost boundless, and will certainly "affect the whole orientation of solar research for years to come". The man in the street may well ask what is the significance of solar research to him, to which the reply is that it was from solar and stellar research that the first hints of the new theories of atomic structure originated. Those theories are now the basis of much of modern physics which is having a tremendous effect on the applications and potential applications of scientific knowledge. If history eventually repeats itself with equal effect, the scientist, who recognises the value of such fundamental research, will evince no surprise.

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S. and G.

Professor E. N. da C. Andrade, F.R.S.

PRESIDENT OF THE PHYSICAL SOCIETY

In the year 1887 a young man named Mr. C. M. Stuart became the first headmaster of a new school at Catford, St. Dunstan's College. To-day that event may seem unimportant, but it is worth recalling that at the time of his appointment Mr. Stuart was very nearly unique among British headmasters; for he was trained as a scientist, and had carried out original research under the aegis of Rudolf Fittig, the German chemist who had followed in Wöhler's footsteps in the field of organic synthesis. When he was mapping out the school curriculum Mr. Stuart decided to try the experiment of introducing practical work into the science course, and as a result the new school became one of the first in the country to be equipped with a science laboratory. Two of the boys who were among those to benefit from Mr. Stuart's novel ideas as to how science should be taught in a secondary school were E. F. Armstrong (whose father was a governor) and Edward Neville da Costa Andrade.

Andrade was born in London in 1887; he was of Portuguese descent, his family having come to England at the time of the Peninsular War. By the time he was sent to St. Dunstan's College the science teaching there had proved itself an outstanding success and young Andrade's scientific inclinations were thus able to develop under unusually favourable conditions. At school he won a scholarship and proceeded to University College, where he studied for a physics degree under Professor F. T. Trouton. An 1851 Exhibition scholarship enabled him to spend a year in Germany, where he investigated the electrical properties of flames in Lenard's laboratories at Heidelberg; this research gained him his Ph.D. *summa cum laude*, a distinction usually reserved only for German students.

After his return to England in 1911, he spent a year working in the Cavendish Laboratory. The following year saw him back again at University College. His new studies were concerned with the flow of metals. This work led him to prepare the first single metallic crystals ever obtained, which was accomplished by slowly cooling metal wire; the technique proved successful with lead, tin and frozen mercury, and was later applied to other metals. These single crystals have rather queer properties; for instance a single crystal of copper at room temperature is very soft and can be "stretched" with great ease, but after a 50% extension its mechanical strength is found to have increased by about 50 times! The study of this and other phenomena connected with single metallic crystals was to engage Andrade's attention over many years.

In 1913 Andrade moved to Manchester University, where he collaborated with Rutherford in gamma-ray research. His work at Manchester was brought to an abrupt end with the outbreak of the Great War, and in September 1914 Andrade volunteered for the Army. He received a commission in the artillery and in 1915 joined a battery of 60-pounders in France. The summer of the following year saw him transferred to a sound-ranging unit attached to a group of counter-batteries on the Arras salient. A number of other young scientists were engaged on sound-location; for instance, Lawrence Bragg, Charles Darwin, A. S. Russell and H. R. Robinson. Theirs was no comfortable staff job; their task was to track down, by means of the ingenious apparatus at their disposal, the enemy batteries that were straffing our lines and to give the exact position of these guns to our batteries. They worked well within range of the enemy artillery,

and it is gratifying to find that several of them were mentioned in dispatches. In 1917 Andrade returned to England after a prolonged spell of sickness; and for the rest of the war he remained attached to the Ministry of Munitions, being occupied in the main with work on explosives.

When the war ended his association with military affairs did not cease. In 1920 he was asked to set up a physics department at the Ordnance College at Woolwich. (A few years later this training establishment became the Artillery College; soon afterwards the name was changed once more, and it was called the Military College of Science.) When Andrade joined its staff, the students of the main course, known as the "Advanced Course", were gunnery officers with at least five years' army service and usually with the rank of either captain or major. The classes which Andrade organised gave them a training in physics equivalent to that provided at a university, though a special emphasis was put upon the military applications of the subject. After passing their course these officers continued their military career, being given technical appointments with the Army. A brief list of some of his ex-students who to-day hold key-positions in the Services and who have great responsibilities in connection with the design, trial and development of new weapons is not without interest; it includes such names as Major-General D. S. C. Evans, Major-General E. A. Woods (Chief Inspector of Armaments), Major-General F. G. Wrisberg (Director-General of Weapons and Instruments Production), Brigadier F. G. Pocock (Deputy Chief Inspector of Armaments), Colonel A. V. Kerrison, Colonels G. O. C. Probert and Lawrence Haines, and Colonel Hodgkinson.

After eight years at Woolwich Andrade returned to University College, to become Quain Professor of Physics in London University. His laboratories rapidly became well-known for the fundamental work done in them. The research was concentrated not upon such revolutionary and spectacular fields as atomic phenomena but upon new problems arising from that basic and homely branch of physics that we call "properties of matter"; the subjects of sound, single metal crystals and viscosity had yielded results of outstanding importance through the investigations of Andrade and his school before his laboratories were wrecked by bombs in the winter of 1940. Not only was all his apparatus destroyed, but he also lost most of his personal research records and his lecture notes.

At the beginning of this war Andrade became scientific adviser to the Director of Scientific Research of the Ministry of Supply; he retained this position until July 1943. When the same Ministry set up an Advisory Council on Scientific Research and Technical Development in 1940 he was appointed a member, and served on that committee for the allotted span of two years.

Outside science he has many interests. In *Who's Who* he lists his hobbies as "golf, poetry, old scientific books and useless knowledge". In his younger days he was a great cricket enthusiast, and one sports writer has suggested that if Andrade's skill as a player had matched his encyclopædic knowledge of the game he would have won his way into a Test team. On his own admission, Andrade finds his chief recreation "in encounter with men who earn their livelihood by other and less desperate shifts than the service of science", which doubtless helps to explain why he has been so successful in interpreting the advances of modern science to the layman.

A subject to which Andrade has devoted much attention is the history of science. The style of his recent lectures on Newton and Banks inspires the hope that it will not be long before he gives us a full-length book about scientists of the past. I cannot pass over his historical interests without mentioning the lecture he gave at the 1927 exhibition of the Physical and Optical Societies. The subject of his talk was electric discharge as it was known at the beginning of the eighteenth century. For the occasion he assumed the character of Hauksbee, who was the first man to obtain electrical discharges in evacuated tubes. Not only did Andrade use Hauksbee's original air pump (borrowed for the occasion from the Royal Society) and a replica of his electrical machine, but he also wore the clothes and spoke the language of the period. Incidentally his audience were spared the suspicion of doubting whether Hauksbee looked anything like Andrade in fancy dress, for he had taken the precaution of finding out that there was no portrait of Hauksbee in existence, a precaution which film producers might consider copying!

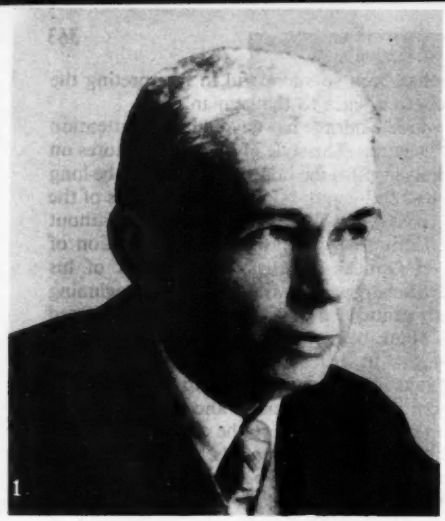
In the same vein was the dedication of his book, *The Structure of the Atom*, to Rutherford; its old-world phraseology stands cleverly counterpointed against the crisp language used in the rest of the volume.

There are two poets in the Andrade family; his wife, who has written much poetry, is the widow of the late Clennel Wilkinson, the well-known naval historian. Andrade himself is a poet of distinction, his book of verses, *Airs for the Hautboy*, and other poems having won high praise from the critics. He is represented in most anthologies of modern verse. Recently he and his wife collaborated on a book that catered shrewdly to the current demand for Brains Trusts and "Quiz" programmes. They called it *The Answer Is*: some of the simple problems in it, such as the one quoted below, have caused plenty of puzzlement—even to members of scientific societies!

> Adolphus said to Hildebrand, "I'll toss you for half the money you have in your pockets." "Right," said Hildebrand, who had £10. What was the state of Hildebrand's finances after they had played the game for a long time during which each won half the tosses?

This brief article would be incomplete without a reference to the "rag" lecture which Andrade used to give each Christmas at University College. The experiments were elaborately contrived to contradict the lecturer instead of to illustrate his remarks. For instance, after Andrade had explained with mock seriousness that when a liquid is heated it expands, he would proceed to heat a piece of apparatus looking like one of those thermometers which certain ink manufacturers distribute as advertisements, but instead of rising in the tube, the coloured liquid was guaranteed to fall to the bottom. (In case the Marx Brothers are interested in this "gag" I might explain that it depends upon sealing the bottom of the tube with wax.) Fellow conspirator with Andrade on those occasions was Mr. L. Walden, whose talents were as invaluable then as at the more serious lectures and in the research laboratory; ex-students of University College will probably be interested to learn that Mr. Walden has received the George Medal for his special work in war research.

WILLIAM E. DICK.



1. A. A. BOGOMOLETZ, President of the Academy of Sciences, UKR.S.S.R., Member of the Supreme Soviets of the U.S.S.R. and the UKR.S.S.R.

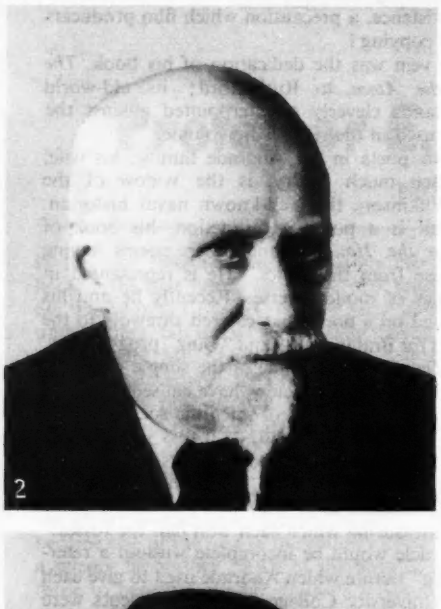
2. Stalin Prize Winner, Academician VLADIMIR KOMAROV, the biologist and President of the Academy of Sciences of the U.S.S.R.

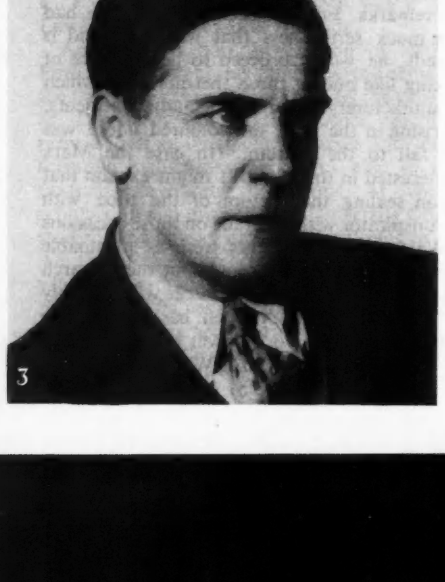
3. Stalin Prize Winner, Academician PETER KAPITZA, Director of the Institute of Physical Problems, Academy of Sciences of the U.S.S.R. and Fellow of the Royal Society of England.

4. Stalin Prize Winner, Academician ABRAM JOFFE, Vice-President of the Academy of Sciences of the U.S.S.R., Director of the Leningrad Physico - Technological Institute.

5. Stalin Prize Winner, Academician ALEXANDER FRUMKIN, Director of the Colloido-Electrolytic Institute.

6. Stalin Prize Winner, Academician TROFIM LYSENKO, President of the Lenin Academy of Agricultural Sciences.





Science in the Soviet Union

HUGH P. VOWLES and W. R. STOKER

PETER THE GREAT built St. Petersburg as a "window opening on the West" for his Russian Empire. It was natural that he should grace his new Capital with an Academy of Sciences on the French model. It was founded in 1724—partly because of Peter's own practical interest in applied science, but probably also for ostentation.

Between Peter's time and the October Revolution of 1917 conditions in Russia were not suitable for the rapid advancement of science. Industry developed late, and then mainly on foreign capital and with the help of foreign technicians. Not all members of the Academy were scientists. Some favourites of the Tsarist government, for example, were granted membership as a sinecure for the sake of the salary. Laboratories were few and poorly equipped. Apparatus had to be imported from abroad.

In spite of these difficult conditions individual Russians made great contributions to scientific knowledge. The names of Lomonosov, Mendeleyev, and Pavlov among others need no introduction.

The period of war, revolution, civil war and foreign armed intervention created difficult conditions for the pursuit of science. The country was in a state of economic chaos following years of widespread carnage and devastation. Production and transport were almost at a standstill. A large proportion of the educated people fled abroad, though some of the ablest scientists such as Pavlov, Joffe and Timiryazev stuck to their posts.

Those who stayed and worked on were the more far-seeing and the more fortunate. Immediately it came into power the Soviet Government devoted the utmost possible attention to science and the needs of scientists. Joffe and others were encouraged to commence training a new generation of scientists. Science has advanced steadily from strength to strength until now its influence and prestige is greater in the Soviet Union than in any other country.

Lenin himself had a knowledge and grasp of science unusual in a statesman. This is clearly shown in his book *Materialism and Empirio-Criticism*. A famous saying of his, "Communism is the Soviet power plus electrification of the whole country", was transferred into action with the formation in 1920 of the "State Commission for the Electrification of Russia." Two hundred scientists and engineers participated in the formulation of a plan covering the restoration and reconstruction of the national economy, with electrification as the indispensable basis.

The majority of foreign experts considered this plan, to say nothing of most other Soviet plans, as far beyond the bounds of possibility. Even so far-sighted a writer as H. G. Wells dismissed Lenin as a "dreamer in the Kremlin" with wild plans of electrification. The critics were wrong. The plan was duly put into operation and has since been greatly extended.

During its first ten years the Soviet government repaired the ravages of war. The commencement of work on the First Five-Year Plan called for a great intensification of scientific work; hence for an increase in the number of scientists, who were also essential for the proper training of engineers. The influence of the Academy and the Universities gradually grew. In its original form the Academy was not suited to the tasks awaiting it. The problem of adaptation and development became more acute in the later years of the Second Five-Year Plan. The numerical strength of the Academicians was more than doubled. The effective strengthening was proportionately greater for technicians, and communist philosophers were now elected for the first time.

In 1917 there were 45 Academicians, 109 scientific workers and 1 institute. By 1938 the corresponding figures were 130, 3420, and 58. By 1941 the number of working scientists had risen to 5000, working in 76 institutes.

In 1934 the Academy headquarters were moved from Leningrad to Moscow. At the time many scientists viewed the move with apprehension. Indeed there were some difficulties of accommodation and temporary disruption of work. The move was undertaken for three main reasons. Firstly, the Government was by then making great use of scientific organisations for the purposes of consultation and planning. It was clearly advantageous for the Government and the leading scientific institutions to be located in the same place. Secondly, Moscow was the new capital and the ideological centre of the new Soviet State. All the most active people worked in or periodically visited Moscow. It was felt that the ideology of the Academy would benefit from the closer contact with these intellectual forces which would be possible in Moscow. Finally, the Academy is vital to the defence of the U.S.S.R., and Moscow was rightly considered to be less vulnerable to attack than Leningrad. The move has been amply justified by events.

Decentralisation and Expansion

The process of decentralisation of scientific work became necessary as the older institutes expanded or as the need for new ones arose. For instance Joffe established the Leningrad Physico-Technical Institute of the Commissariat of Heavy Industry in 1918. At first the Institute occupied a few rooms in the Polytechnical Institute. The primary object was to train physicists by the provision of research facilities. The Institute soon acquired its own building and these were later extended. By 1930 it had grown too large for convenience, the total staff amounting to some 2000 people, including 700 physicists.

The nucleus of trained scientists having thus been formed it became necessary to start new Institutes in various parts of the country. One Institute was formed at Kharkov, probably in connection with the development there of the tractor, electrical, and other industries. Dniepropetrovsk was chosen as the site of another Institute, partly because of the proximity of the great Dnieproges power station with its associated metallurgical, electrical, and electro-chemical works. Again, an Institute was founded in Tomsk as one of the main intellectual centres of Siberia with a long University tradition. Another was formed at Sverdlovsk in view of the rapid industrialisation of the Urals. These last two centres have

proved of special value under war-time conditions, as they are remote from the possibility of attack yet situated near growing industrial regions. Various departments of the Leningrad Physico-Technical Institute also branched off as new Institutes.

In connection with the growing needs of the country similar expansion took place simultaneously in other branches of Soviet science. Many expeditions of all kinds were sent out. Geological expeditions discovered natural resources which altered the entire conception of the potential mineral wealth of the Soviet Union. Their work has had a profound influence on the conduct of the war, as indicated by the discovery and development of oilfields so large as to be comparable with Baku.

The northern sea route round Siberia from Archangel to Vladivostok was developed into a regularly used sea-lane. This called for an immense extension of meteorological, hydrographical and similar work. The Leningrad Arctic Institute was founded and has done considerable work on ice formation and behaviour. The Papanin Expedition in which four men and eleven tons of equipment were landed at the North Pole from aircraft, and drifted to the shores of Greenland, is a fine example of such work. Radio communications and weather reports were radioed to the mainland, and had a considerable bearing on the success of the non-stop flights from Moscow to California over the North Pole which Soviet aviators made about this time. It is interesting to note that the planes used to land the equipment were very similar to the regular four-engined bombers then in use in the Soviet Air Force. A further interesting fact in connection with the working of the North Sea Route is that radio direction and distance finding methods were used in making the basic triangulation when mapping parts of the Kara Sea. This was necessary owing to the prevalent local fogs. Another notable use of these methods was the development by Soviet scientists of apparatus for use on ships to indicate the presence of other ships or land when steaming in foggy conditions.

Biological expeditions were sent as far afield as South America and Abyssinia. The discovery of many new species of potato in South America made possible considerable improvement in the qualities of that vegetable.

Expeditions of archæologists and historians made discoveries concerning the history of the Slavonic peoples which have probably played a considerable part in strengthening the national pride and patriotism of Soviet citizens.

In order to understand the reasons for this rapid expansion of science under the Soviet government the Communist philosophy of dialectical materialism must be examined briefly. This is equally necessary in order to understand some of the organisational peculiarities of Soviet scientific work which are to be described below.

Dialectical Materialism

Dialectical Materialism is the philosophy of the Communist party. It was originated by Marx and Engels and considerably developed by Lenin and Stalin. This philosophy is materialist in that it considers matter, the objective world, to be primary or prior to thought which is regarded as secondary. Thought is inconceivable in the absence of matter that thinks. Our conception of the Universe is a reflection of objective reality in the mind. Since thought ultimately depends on the material environment of the thinker its full significance can only be found in a full understanding of the material basis. Thus science in its widest aspects provides the key to all other knowledge.

The dialectic was suggested to Marx by his studies of Heraclitus (who said πάντα ρεῖ "all things flow") and Hegel. It considers the world to be in a state of movement and change. An object can only be fully understood in its relation to its past history, present environment, and probable future development. Stalin wrote: "Contrary to metaphysics, dialectics holds that Nature is not a state of rest and immobility, stagnation and immutability, but a state of continuous movement and change, of continuous renewal and development, where something is always arising and developing and something always disintegrating and dying away."

Dialectical materialism teaches that there are certain guiding principles which should be borne in mind in the study of phenomena of all kinds.

One of these guiding principles is known as the Unity of Opposites. Lenin pointed to the contradictory, mutually exclusive opposite tendencies in all phenomena and processes of nature; tendencies which, despite their opposition, are complementary in the sense of together forming a unity. An example given by J. B. S. Haldane will serve to make this matter clear. Consider a community of plants and animals. All the members except green plants, certain bacteria and a few others live by consuming other members. Yet these warring members form a unity which can be upset by altering the number of any one of them. If wolves eat deer which eat plants a rough equilibrium is established. If the wolves are killed off the number of deer increase until limited by starvation. There are somewhat more deer, but mostly half-starved. Hence some killing by beasts of prey is necessary to keep herbivora in good health.

The biological process of metabolism—a balanced combination of anabolism or building up, and catabolism or breaking down—is another good example of the unity of opposites.

Another fundamental principle of dialectics is the transformation of quantity into quality, and vice versa. This transformation may be a process within a material system. The quantitative removal of heat from water causes a steady fall of temperature until the freezing point is reached. Then there is a qualitative change as ice forms. Quantitative addition of similar groups to hydrocarbon molecules results in qualitative changes in the properties of the compounds produced.

The quantum theory illustrates the dielectic relation between quantity and quality. An atom in which the spin energy alters too much from the current quantum level of the atom, undergoes a discontinuous quantitative and qualitative change as its energy is altered by one quant.

The final dialectical principle to be mentioned here is the Negation of the Negation, whereby the contradictions occurring within a system lead to further development. In his *Dialectical Materialism and Modern Science*, J. B. S. Haldane illustrates this as follows:

"The most primitive organisms merely grow and

divide. If they break down the large molecules of their bodies into smaller molecules which are excreted, this is a negation of their life process. But in higher animals the breakdown of relatively large molecules, such as glycogen and adenosinetriphosphoric acid, is the immediate source of the energy of muscular movement, which enables them to get food which is quite unavailable to the simplest organisms. The negation of growth thus negates itself."

It is this dialectical concept which elucidates the Soviet attitude to the relations between theory and practice or between pure and applied science. All science may be utilised sooner or later to modify the material conditions of life. That which we know as "applied" science is applied sooner. That which we know as "pure" science is applied later, but is none the less important for that. In the development of theory and practice, observation of certain practical facts leads to the formulation of a theory to cover them. The theory serves as a guide to further observation. This brings to light new facts which negate the old theory wholly or in part. A new theory must then be developed.

So many misconceptions arise as soon as the word "materialist" is mentioned that certain explanations are called for. Dialectical Materialism ascribes priority to the objective world but does not deny the potency of the idea. Ideas and thoughts indeed exert a very powerful influence on material affairs. This was repeatedly emphasised by both Marx and Engels. For example, the well-known saying that "philosophers have only interpreted the world in various ways; the point, however, is to change it" clearly indicates the view that ideas should be utilised to influence material change. The same belief is exemplified in the Soviet practice of building special Institutes for outstanding scientists and of taking full account of the abilities of available scientists in formulating plans for future work.

It is frequently implied that "matter does not exist", since the atomic and electronic "bricks" of which the universe is built are clearly not solid indivisible particles, but have many of the properties of waves as well as those of particles. Hence it is assumed that matter is not "real." Dialectic materialists would answer that such an assumption is neither philosophical nor scientific, and that this unity of opposites in the basic structure of the universe is entirely in accordance with their philosophy. The idealists prove by their everyday actions their firm belief in the reality of the objective world.

Planning of Science

The subject of planning invariably arises during discussions on the U.S.S.R. Controversy on the planning of science has enlivened the pages of British scientific journals. Let us therefore glance at Soviet planning of science.

Soviet theorists contend that many of the ills of our modern world, such as unemployment, under-consumption and overproduction, arise because private ownership has become a fetter on production. Although science has been applied to industry and production has been extensively socialised, resulting in an unprecedented expansion of productive capacity, nevertheless the means of production remain under private competitive control. Thus despite remarkable progress, there is, it is alleged, a vast amount of unnecessary conflict and waste. Individual industrial units may be—and often are—admirably planned, but owing to conflicting interests there is lack of comprehensive and co-ordinated planning of industry as a whole. The result, as pointed out to President Roosevelt by the National Resources Committee, is that industrial practice necessarily lags behind scientific knowledge.

Soviet spokesmen claim that in their country the socialisation of production has been carried to its logical conclusion. The means, as well as the processes, of production have been socialised. This makes it possible to take full advantage of scientific knowledge through comprehensive planning of the national economy in all its aspects. The chaotic results of determining the quantities of things which must be provided, by the return on privately invested capital, is replaced by an objective determination of the needs of society. An estimate is then made of the industrial and other equipment required to produce the things needed.

The actual procedure is complex. The State Planning Commission, one of the most interesting and original features of Soviet life, initiates plans from the top. These plans may be, and usually are, considerably modified from below before their final acceptance.

Science enters into this process of planning in various ways. The Academy of Sciences is responsible to the Supreme Soviet. Part of its task is to advise the State Planning Commission on available resources. Scientific research must also be planned in accordance with the needs of the people as estimated by the State Planning Commission.

It is this planning of research which is most liable to arouse controversy. War-time conditions must by now have made it clear to many working scientists in this country that planning is necessary to efficient work. Planning is not incompatible with individual enterprise, particularly when, as in the Soviet Union, the plans are thoroughly criticised from below. Indeed it may be contended that individual scientific enterprise can only bear its full fruit when adequate funds and facilities are provided. Freedom of action is of little use to a scientist who cannot afford apparatus. We have already seen that individual ability is encouraged to the extent of providing special Institutes for outstanding scientists. This is symptomatic of the Soviet attitude. The reason is that a plan, to be a good plan, must take full account of the abilities of available men.

The co-ordination of scientific work by the Academy eliminates overlapping of work and ensures that a scientist working on any particular problem shall know of any parallel work being carried out elsewhere.

In the experience of one of the present writers (W. R. Stoker) of research work within a Soviet Institute plan, the planning is not too rigid or formal. A reasonable estimate of expenditure must be provided. The sum allocated must not be exceeded without good cause. The general plan of the work is elaborated together with the senior scientist responsible. Details and new branches of the plan are filled in periodically as the work proceeds. Each research theme is discussed periodically at laboratory meetings. Reviews of progress are made and suggestions offered, whilst criticisms must be answered. To a junior

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7. Stalin Prize Winner, Academician EVGENII TARLE, the historian.

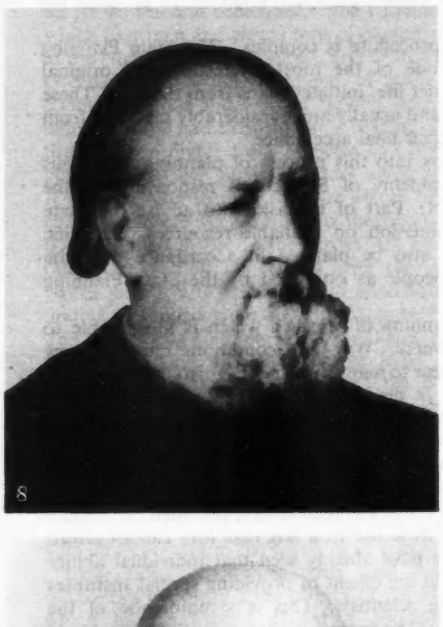
8. Stalin Prize Winner, Academician ALEXEI KRYLOV, mathematician and shipbuilder.

9. Stalin Prize Winner, Academician ALEXANDER FERSMAN, Director of the Institute of Geological Sciences.

10. Academician N. SEMYONOV. His works *The Theory of Chain Reactions* and *The Heat Theory of Combustion and Explosions* bring science closer to the solution of the problems of combating detonation.

11. Stalin Prize Winner, Academician SERGEI SOBOLEV, Director of the Institute of Mathematics, Academy of Sciences.

12. Stalin Prize Winner, Academician IVAN VINOGRADOV, the mathematician.



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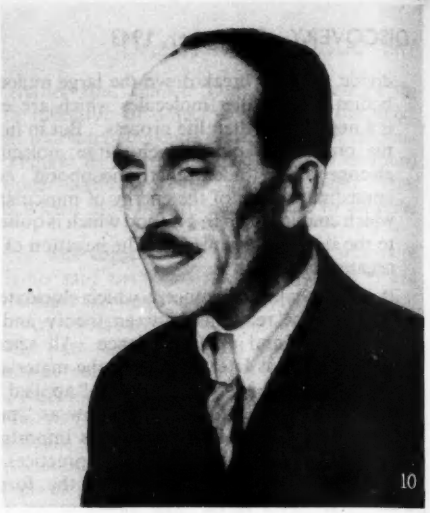

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Photographs: Society for Cultural Relations with the U.S.S.R.

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research worker the process was very stimulating. A variety of trained minds approached the problem from different angles. Mathematicians, physicists, and other specialists were available and could be referred to for advice. It should also be mentioned that in the Moscow Power Institute (an electrical technical college of the Commissariat for the Electrical Industry) during the time of the author's work there from 1935 to 1940, auxiliary services such as those of fitters, electricians and machine shops were on a better scale than in the British colleges of which he has had experience.

Other Scientific Organisations

Much scientific work is not directly controlled by the Academy. The Industrial and Agricultural Commissariats have their own Technical Colleges and also their own large Institutes working on fundamental problems. For example there is the All-Union Electrotechnical Institute working on many aspects of electrical engineering. Research on industrial problems beyond the scope of factory laboratories, or not of immediate interest to them, is often carried out in the Technical Colleges. The factory laboratories are concerned with more immediate problems. The scale of their finance is generous. Their results are rarely published. Research of a more abstract nature is carried on at the Universities.

Probably owing to the general shortage of trained personnel, but at least partly as a matter of policy, these various organisations are interlocked in personnel. For example, Academician K. I. Shenfer held the Chair of Electrical Machines in the Moscow Power Institute; he was consultant to the "Dynamo" factory; and he served on committees of the Academy of Sciences. Similarly E. K. Kondorsky lectures in the Physics Institute of Moscow University and carries out research there on magnetism under the leadership of Akulov. He also works in an Institute of the Academy of Sciences and acts as consultant on physics to a few post-graduate students of the Moscow Power Institute.

A good example of organisational collaboration is the work of the Commission, organised by the Academy shortly before the outbreak of war, to compare possible electric traction systems for use on the Soviet railways. Much of the work was done by workers of the Transport Section of the Academy. Representatives of various commissariats, factories, research organisations, and others concerned were drawn into the work. The individual studies were unified into a common style and plan by a special committee.

The various systems of electrification of railways were analysed from the aspects of technical and economic advantages and general State advisability. Lines totalling some 19,000 track miles likely to be electrified in the not distant future were studied with a view to using the most favourable system. A large number of different systems of electrification were compared in detail from a wide range of aspects. A novel system considered was that using 6000-v. direct current in the overhead contact wire. This system was first developed in the U.S.S.R.

For another novel system (using 50-cycle alternating current in the contact wire, with a grid controlled mercury-arc rectifier and direct current motors installed on the locomotive) a complete locomotive and trial line were built by the Dynamo factory. This plan was developed simultaneously with and independently of the development of a similar locomotive abroad. The system was found to be very promising. It was particularly favourable in that it offered the best possibilities for schemes using direct current at much higher voltages in the contact wire, with "direct current transformers"—ionic apparatus—on the locomotive.

Problems associated with the effect of traction loads on power systems and traction interference with communications were studied. Mathematical theory of statistics and of probability was developed and used in assessing the results obtained.

The Commission has now reported to the Government, and it is to be expected that the electrification of Soviet railways after the war will be profoundly affected by its work.

Another aspect of Soviet organisational work in technology worthy of mention here is the intensive development of standardisation. This work has been carried out with much attention and care to ensure interchangeability of parts and economy in manufacture without fettering development. A close study of Soviet standards for his particular branch of industry would benefit almost all British engineers.

Scientific Achievements and Personalities

Detailed knowledge of Soviet scientific achievements and results is rare in this country. British scientists who participated in the Physiology Congress organised in Leningrad and the Geology Congress organised in Moscow gained a fair insight into the work of their Soviet colleagues. British physicians have recently examined with considerable interest the work of Soviet medicine in war-time. Nevertheless, contact between scientists of the two countries has been far from adequate. This has been disadvantageous to both sides. It is to be hoped that the fulfilment of the Anglo-Soviet Treaty after the war will result in an extensive interchange of scientific representatives and information.

It is, however, obvious from the way the Soviets have conducted their part in this most technical of wars that they have a sound technical and scientific background. The fact that before the war Soviet Higher Technical Colleges and Universities had some 150,000 students, as many as Gt. Britain, France, Italy, Germany and Japan taken together, is no mean scientific achievement—especially having regard to the much greater combined population of these other countries.

The latest general review of Soviet science available in this country was given at the Sverdlovsk Session of the Academy of May 1942. The veteran President of the Academy, V. L. Komarov, reported on correspondence between Stalin as head of the Government and himself as President of the Academy on the participation of the Academy of Sciences in the war effort. Komarov himself has done valuable work in organising a Commission of the Academy on the mobilisation of the resources of the Urals, Western Siberia, and Kazakhstan. He was awarded a Stalin prize for this work.

Academician A. F. Joffe reported on physics and the war. He pointed out that in the Soviet Union the outbreak

of war had not made it necessary to improvise organisations for the co-ordination of scientific effort, as had been the case in this country and the U.S.A. Consequently Soviet war organisation of science is on a much higher level than elsewhere. The four Physics Institutes of the Academy, the State Optical Institute, and the Physics Institutes of the Universities are now fully mobilised for war. He remarked that in war-time "speech is silver but silence is golden" so far as major developments are concerned, implying that he could not divulge many details of achievements. Still, some interesting points were made. The combination of monochromatic sodium vapour lighting in factories with blue window glass opaque to this light but transparent to a large part of ordinary daylight, has made possible reasonable daylight illumination of factories. Results achieved in Radar, supersonic underwater detection, de-icing and altitude problems in airborne equipment and the like seem to be comparable with what is going on in this country. Many physicists have now become familiar with production conditions and problems for the first time. It was Joffe who formed and guided the work of the Military and Naval Commission of the Academy of Sciences. (In parenthesis it may be noted that apart from the planes of the Fleet Air Arm the Soviet Air Force comes under Army control.)

Academician P. Kapitza, F.R.S., who formerly worked in Cambridge, is now in charge of the Moscow Institute of Physical Problems built specially for his work. He has done valuable work on the liquefaction of gases by a new and highly efficient method. The gases are cooled by being made to do work in a small turbine. Distillation of liquid air produced makes available cheap supplies of oxygen. This gas is of great value in war for altitude flying, welding and other purposes. It has also been used in the U.S.S.R. to enrich the blast of blast furnaces, with great increase in output. The nitrogen produced has been partly used in the explosives industry. As reported in a recent issue of DISCOVERY this work won Kapitza the Order of Lenin. Other workers of the Institute were also awarded Orders and Medals.

Academician Orbeli reported on Biology and the war, describing new organisational forms in scientific work during war-time. Direct contact between Leningrad physiologists and the Military and Naval commands proved fruitful. Biology had been mainly devoted to improving the food supply and to civilian and military medicine. Great efforts had been made to popularise the results of the work amongst the farmers.

Academician Lysenko, famous for his work on the vernalisation or pre-germination treatment of wheat and other seeds, reported on agricultural achievements. Work had been done on improved methods of storing crops. The most outstanding contribution was probably the growing of potatoes by planting not whole tubers but only the eyes together with a small portion of potato. The method was adopted successfully on a large scale. The potato crop was greatly extended and the bulk of the seed potatoes used for food. There have been extensive developments lately in the breeding and artificial insemination of cattle.

It was also reported that considerable improvement of fuel and oils for internal combustion engines had been effected. Mathematical research has been applied to aircraft design, astro-navigation and artillery fire. There were investigations on the theory of films, plastic deformation and the turbulent flow of fluids.

As a contribution to the development of the social sciences much research is being undertaken on the history of the Slavonic peoples, the U.S.S.R. and the war.

Semenov, Frumkin, and Talmud have extended their work on the kinetics of chemical reactions. This has influenced the design of gas generators using straw or wood chips as automobile and tractor fuel, as well as the underground gasification of coal. Underground gasification is now being developed on a large scale without the necessity for any mining work. Means have been found for controlling the spread of the process in the seam. It is claimed that a larger proportion of the coal is usefully won in this way than is possible by ordinary mining methods. Semenov is the Director of the Institute of Chemical Physics, where work has been conducted on surface phenomena.

Professors Mandelstamm and Landsberg of Moscow University independently discovered the Raman effect about the same time as Raman (see DISCOVERY, IV, p. 256).

Rebinder has been responsible for much of the work on surface effects mentioned above. He holds original views on the relationship between science and industry. He contends that scientists will be more usefully employed in leading economic development and in discovering the possibilities of creating new industries than in making minor improvements to existing industries.

Conclusion

The best that can be expected of such a brief review of so far-reaching a subject as Soviet science is that it may stimulate the reader to seek further information about it. Those interested are referred to *Soviet Science* by J. G. Crowther, Director of the Science Department of the British Council, and to the same author's more recent Trueman Wood lecture before the Royal Society of Arts. *Soviet Science*, a somewhat abridged edition of which has been published by Penguin books, provides an admirable survey of the development of scientific thought and work in the U.S.S.R. *Science in Soviet Russia*, edited by Joseph Needham, may also be recommended for further reading. For progress in electrification up to 1935 reference should be made to *Electric Power Development in the U.S.S.R.*, a collective study prepared under the guidance of Academician B. I. Weitz.

Papers in English, French and German are available in "Comptes Rendus (Doklady) de l'Acad. des Sciences de l'URSS." Similar material has also been published in "Acta Physicochimica", in "Technical Physics of the U.S.S.R." and "Phys. Zeitschrift der Sowjetunion" or in the journal which has replaced these latter two—"The Soviet Journal of Physics." To those fortunate enough to have a command of Russian, a wealth of material is available, though much of it is difficult of access in this country.

FIG. 1.—Food relief in Hungary in 1921

Relief and Reconstruction

J. R. MARRACK, M.A., M.D.

THOSE of us whose memories are long enough and, still more, those of us who have read again the writings of 1917 and 1918, must realize how very closely the pattern of speech and thought recur. We are again promised a new world, age old injustices will disappear, lion and lamb will gambol together; but we are not told how such changes are to come about. We can well feel that, when the fighting ends, we shall again go back to the old system, without even the confidence in its working that sustained us before 1914. Indeed, the retreat did not begin last time until after the armistice; this time, politicians have already begun to vie with each other in whittling down the promises that were made so freely in the dark days of 1940 and 1941.

But there are differences. We have the lesson of last time. True this may work both ways; we realise that vague projects for the amelioration of the universe will get us nowhere; but we may also be driven to a cynical distrust of any plans for a better future and to a belief that war and suffering are inevitable—"human nature cannot change." What is more decisive is that people at large have begun to think on these lines: we are now devoting a large part of our productive capacity to war; millions of men who in peace time could or should make goods for our use are in the forces; raw materials that could make our houses, our furniture, our clothes, instruments of study, recreation and pleasure, that could feed us and the livestock that we should eventually eat, all are being cast into a vast bonfire of destruction—yet we still have enough to keep us alive and well; if we could use the labour of these men, all these goods to serve our health, our comfort and our happiness, could we not have that world fit for heroes that was promised

25 years ago? In 1919 the difficulties and mistakes of the early stages of Food Control biased opinion against control of any kind; now, we have had years of experience of successful Food Control, and are asking whether control guided by the needs and wishes of consumers could not make as good use of this possible plenty as it has made of scarcity. For the first time real economists have broadcast real economics to the people at large; they have explained that the essentials are goods and services and that the financial machinery of money and credit is adaptable to the purpose that we wish it to serve. And an ever-growing body of men and women who have had a scientific training realize the immense possibilities of science applied to human welfare.

It is in this more favourable atmosphere that we have, already, certain precise plans and programmes that deal with concrete matters. At home, the Beveridge plan which has been read and discussed far more widely than any like schemes in the past; abroad, the draft of the United Nations-Relief and Rehabilitation Administration (U.N.R.R.A.) and the findings of the United Nations Conference on Food and Agriculture at Hot Springs: both of these deal primarily with food. If the Relief and Rehabilitation for which the draft of U.N.R.R.A. sets out the machinery are carried out with the recommendations of the Hot Springs Conference as their objective, we shall be on the road to the full use of all that the world can now produce and that future developments of science promise for our own welfare. But at the end of the war we shall be at the parting of the ways; if we take the wrong road then the chance may not come again.

What is Relief?

Private organizations appeal for support and publish accounts of their activities. They describe the special machinery set up for feeding undernourished children or even a large proportion of a famine stricken population—hence the common idea of relief work as the running of canteens by foreigners. But the greater part of relief cannot take this form. In the first place the scale is too large. A country impoverished and disorganized by war needs to import abnormal quantities of goods; but the same poverty and disorganization make it impossible to obtain the goods by ordinary trade transactions. All goods supplied by machinery, set up by private organizations or by governments to meet this dilemma, are included under the heading "relief". After the last war the total amount supplied after the armistice through organizations which Mr. Hoover directed cost £264 million. Actually this relief was insufficient, and we can anticipate that much more will be needed after this war. Private charity can supply only a minor part of relief; the bulk must come from Governments.

Relief in the form of food, clothing, medical supplies and seeds, provided during and after the last war, was financed as follows:

Relief to Belgium and North France:

Total	£52 million
Credit	77·0%
Cash	0·7%
Benevolence	22·3%

Armistice Period to Europe: (November 1918 to September 1919).

Total	£220 million
Credit	61·2%
Cash	37·3%
Benevolence	1·5%

Reconstruction: (September 1919 to June 1923).

Total	£44 million
Credit	34%
Cash	12·5%
Benevolence	53%

During the Armistice and Reconstruction period the funds supplied by benevolence went mainly to feed children and for Relief to Russia during the famine period 1921 to 1922.

Secondly, relief is not limited to the supply of food. Hunger will set one of the most urgent tasks, but one of the simplest. Over 20 million people—prisoners of war, forced labourers, deported populations—have been taken far from their homes. When fighting ends they will begin to straggle home, blocking railways and roads, eating up food supplies as they pass, carrying with them lice infected with typhus and the germs of cholera and typhoid. The policing and sanitary control of this vast migration will set a colossal problem. Typhus has already invaded Central Europe and Spain. As soap, fuel, clothes and food become scarcer, it may get completely out of control. All the resources of medicine are being recruited to fight these plagues. But the control of typhus is far more a matter of soap, fuel and food than of medicine.

Relief at the end of the first World War was directed almost entirely to urgent and immediate needs. Such relief is essential, for men cannot work when they are ill and starving. But relief is most valuable when it supplies the goods that will set people back on their feet so that they can supply their own needs. The crops of cereals in continental Europe in 1920 were less than three-quarters of the average of the years 1909 to 1913; in Germany they did not rise above 70% of the 1913 level until 1924-25, although the loss of territory would account for a reduction of only 14%. In France the number of cattle was 16% below the pre-war level in 1919 and was restored only in 1924. Industrial production and mining in Continental Europe in 1919 were only half what they had been in 1913; they took five years to recover. At the end of this war the destruction of rolling stock, of docks and railway stations, and of factories will be on a far wider scale; the Nazis will continue to plunder and lay waste the countries that they quit; the peoples of Europe will be less able than before to restore their industries and agriculture unaided. And we now have two wars on our hands; Europe should, if possible, be able to produce a large proportion of its food before the larger problem of feeding the Far East can be tackled.

To become self supporting Europe must be supplied with livestock and seeds, farm implements, machinery, raw materials and rolling stock. If relief of this kind is not provided—enough and in time—recovery in Europe will be slow, and the people will be in no mood for the fundamental changes which the long-term programme of the Hot Springs Conference involve.

FIG. 2—Primitive conditions for child feeding in Hungary in 1921

Relief, 1919 to 1923

Herbert Hoover, who was Director of the Commission for Relief in Belgium from 1914, Food Administrator in the U.S.A. from 1917, Director-General of Relief under the Supreme Economic Council, Chairman of the European Relief Council of the U.S.A. and of the Committee of the American Red Cross for Relief in Russia, had an unusual qualification as administrator of relief—he had been trained as an engineer. His idea of relief was that of an engineer tackling a job; he did not collect inadequate and uncertain amounts from the stage army of the good and give the proceeds as charity, but drew up estimates of the amounts needed, bought these amounts, and supplied them as a business proposition. The relief to Belgium during the German occupation was run largely on these lines; three-quarters of the goods were supplied on credit to the Belgian Government. Apart from interruptions due to the exigencies of war, food was supplied according to programme and, if not generous, was enough to prevent grave want. An example of the reverse type was seen in Russia during the famine of 1921-22. Eighty per cent was given; mainly for political reasons large-scale relief came too late; the total amount sent to 30 million starving people was less than that sent to the 8 million people of Belgium in the one year, November 1917 to 1918; millions died of starvation. With all respect for the devotion of those who faced all the hardships and dangers of Russia in that ghastly year, and the generosity of those who subscribed the relief funds, we must insist that we shall not see that kind of relief again. We shall, however, see it again, unless sufficient stocks are accumulated and full preparations for distribution are made now.

Various reasons made the Administration of Relief to Europe between these two periods unsatisfactory. Little preparation had been made before November 1918. Then owing to differences of opinion between the Allies and the U.S.A. with regard to control, the setting up of an organization for relief was delayed until the end of December. The problem proved too complex for this body, which had meagre powers. It was only in February 1919 that the Supreme Economic Council to supervise all economic activities of the Allied and Associated Governments was set up; thereafter, relief was administered by the Food Section of this Council, with Hoover as Director-General. The first Relief Programme was not submitted until nearly three months after the Armistice. The experienced bodies, the Allied Maritime Transport Council and the Inter-Allied Food Council were not used. De-control of shipping began in February 1919, when

relief was getting under weigh; ships were used to fetch unessential goods for the more wealthy countries, and the satisfaction of Europe's needs was limited and delayed by lack of tonnage. Above all the abrupt withdrawal of economic controls in the U.S.A. at the end of 1918 reduced the possibility of joint Allied action in procuring supplies.

The greater part of the relief provided after November 1918 was supplied through the Food Section of the Supreme Council during the period February to September 1919. The goods were supplied to the Governments of the recipient countries and usually distributed by them, much as food which our Government now acquires is distributed to us—that is, through the normal channels of trade. After the signing of the Peace Treaty in July 1919 this official relief came to an end; much smaller amounts were provided during the following four years, mainly in the form of meals for children, administered by voluntary organizations and comparable in form to our school meals.

Quantity and Quality

The food provided after November 1918 was not only late, but also too little. In general, home production of cereals in Continental Europe was more than 25% lower in 1919 and 1920 than in 1913; the fall was more severe in the countries other than the Neutrals and Western Allies (France, Belgium, Italy, Portugal); animal products must have been reduced considerably more. But with this reduction of home supply, imports of food (including relief) into Europe (other than the Neutrals and Western Allies) were 18% less in 1919 (when official relief was supplied) and 31% less in 1920 (when relief was supplied mainly to children) than they had been in 1913. Relief did not even bring the yearly imports of food up to the normal level, much less compensate for the deficiencies of home production. In particular, over 3¼ million children were supplied with meals in the summer of 1920 and 2¾ million in the summer of 1921—this was before relief in the U.S.S.R. began. These children were selected children who showed signs of undernutrition. If so many children were underfed, it may be assumed that a large proportion of adults were underfed also.

Most of the finance for relief was supplied by the U.S.A. It was definitely specified that only food produced in the U.S.A. should be bought with the funds so provided. As control of food supplies had been abandoned in the U.S.A. at the end of 1918, the only foodstuffs that could be obtained on any scale were those that had been produced in excess of demand. Production of food, especially of grain and pork products, had been stimulated during the war to satisfy the demands of the Western Allies. Grain harvests had increased by one-third—about 7 million tons; production of pork and lard had risen by over 30%—1·1 million tons. Shortly after the Armistice the United Kingdom—the chief buyer—cancelled orders and went to cheaper markets. There were, therefore, surplus stocks of these foodstuffs in the U.S.A., large in comparison with normal demands, but not large in comparison with Europe's needs. The total 5·21 million tons of food supplied during the Armistice and Reconstruction periods was made up as follows:

	Armistice Period	*Reconstruction Period*
Flour and Grain	61·0%	81·3%
Rice	2·7%	3·2%
Beans and Peas	2·8%	3·0%
Pork Products	7·2%	1·9%
Milk (condensed and evaporated)	1·4%	6·7%
Cocoa	—	0·7%
Sugar	1·2%	2·9%
Miscellanous	23·8%	0·3%
Total	3·66 million tons	1·55 million tons

The amounts of flour and grain supplied in 1919 were not enough to compensate for the reduction of the bread-grains, wheat and rye, in Germany alone. While to meet the even greater scarcity of animal products in Europe, the chief items were pork products (lard and fat bacon that supplied little protein) and a little milk. Meals for children who had gone through years of privation provided Calories, but little first-class protein and very little of any of the vitamins. It is not surprising that the American Red Cross found in March 1921 that 60% of the Czechoslovak children receiving meals still remained undernourished and lacking in vitality.

However, the need for food was better met than that of other commodities—possibly because Hoover, whom Keynes described as the one man who brought a breath of reality into the Peace Conference, was concerned mainly with food. Table I shows an extraordinary contrast between the flow of overseas imports of raw materials and finished goods into the Western Allied Countries (France, Belgium, Italy and Portugal) and that into "other countries" (Germany, Austria, Czechoslovakia, Hungary, Yugoslavia, Bulgaria, Roumania, Greece, Finland, Estonia, Latvia, Lithuania, Poland). The Neutrals occupy an intermediate position.

TABLE I

OVERSEAS IMPORTS INTO CONTINENTAL EUROPE IN 1919 AND 1920

(*expressed as per cent of these imports in* 1913)

	Food		*Raw and semi-manufactured goods*		*Finished goods*	
	1919	1920	1919	1920	1919	1920
Western Allies	199	120	90	73	205	107
Neutrals	60	43	75	72	153	124
Other Countries	80	68	6	21	45	38·5

The resources of the "other countries" had been depleted much more seriously than those of the Western Allies. The acquisition of raw materials by "other countries" was left almost entirely to the quite inadequate buying, borrowing and bargaining power of the individual countries, and the contribution of private bodies, such as the Society of Friends. In the absence of an international scheme for furnishing raw materials they could not get

enough to run their factories; they were, therefore, unable to make goods which could have been exchanged for further raw materials, for the food that they still needed in the following years and for manufactured goods wherewith to restore their industries. The Supreme Economic Council did not lay down any policy to decide the scale of relief, but later the American Relief Administration stated frankly that its object was not to relieve poverty, as such, but to prevent starvation. There is nothing to suggest that this policy was not followed throughout.

The Present

The Inter-Allied Post-War Requirements Bureau has made detailed estimates of the amounts that each country will need, on the basis of present supplies. These estimates are not limited to the goods necessary to restore the health and efficiency of the people—food, clothing and medical supplies—but include the seeds, livestocks, raw materials, and manufactures that will be needed to restore production. These estimates apply only to eight countries: Belgium, Czechoslovakia, France, Greece, The Netherlands, Norway, Poland and Yugoslavia; but they will, at least, give an idea of the scale of relief needed by Europe as a whole. We are therefore in a better position now than in 1918; we have an estimate of the amounts that will be needed not only for immediate relief but also for reconstruction.

On 9th November the delegates of 44 Nations signed the agreement for the establishment of the United Nations Relief and Rehabilitation Administration (U.N.R.R.A.). The purpose of the Administration is (Article I, §2a of the Agreement).

> "To plan, co-ordinate, administer or arrange for the administration of measures for the relief of victims of war in any area under the control of any of the United Nations through the provision of food, fuel, clothing, shelter and other basic necessities, medical and other essential services."

The Administration might therefore attempt reconstruction and not confine its activities to the relief of urgent needs such as that of food. But the satisfaction of food requirements will come first. In 1919 the Soviet Union was excluded from the Relief schemes. Now, since the Soviet Union is represented on the Central Committee of the Council of U.N.R.R.A., some 40 millions of East Poland, Ukraine, White Russia and the Volga regions must be included among the people who will receive relief—making a total of over 400 million.

On the basis of what we know of food production and distribution, we can estimate that these 400 million will need to be supplied with some 700 Calories per day until the next harvest. One ton of concentrated foodstuffs (such as grain) will provide 3 million Calories; so that 400 million people will need between 2 and 3 million tons of food per month. With regard to stocks, all that we know definitely, is that the Wheat Agreement, signed a year ago, provides that Australia, Argentina, Canada and the U.S.A. shall hold a reserve of 100 million bushels (2·7 million tons) of wheat—that is one month's supply. It has been said that stocks of grain held by Australia, Argentina and Canada amount to some 30 million tons. If this were so, there should be no difficulty in meeting the needs of cereals and therefore of putting a foundation to food relief; but it is now stated that supplies of cereals, even, are insufficient. Animal products—meat and milk—will certainly be scarcer than cereals, as large numbers of livestock have been killed off and those that remain are underfed. Although cereals must make up a large proportion of the relief, recovery from the privations of the last four years, especially among children, will be slow if these animal products are not supplied. It is now known that there is no reserve of non-perishable animal foods (tinned milk, meat and fish) on anything like the scale needed. Animal food could also be furnished in semi-perishable forms, such as cheese and bacon, but these would have to come out of current production. Vitamin preparations will be needed in some places and at certain times of the year. There should, however, be no difficulty in supplying all that is required, except possibly of vitamin A. But, vitamin preparations are no substitute for solid food, and the needs of cereals and animal foods will remain just as high however generously vitamins are supplied.

It has been argued that the need for food may be less than estimated by, for example, the Allied Post-War Requirements Bureau. It is assumed that peasants not only eat the extra food that they are allowed under the rationing systems, but reserve considerable amounts of their produce for themselves. They probably eat more of certain foodstuffs of which it is not possible to keep an accurate check—mainly animal products such as eggs, milk and pork, but also potatoes. As their livestock become fewer and thinner peasants will eat less and less off the ration. In the more primitive areas the peasants may take cereals directly from their own produce for home consumption; but in Western Europe, where cereals are ground in large mills, this is no more possible than in England. In the same way, where grain is thrashed with flails the peasants can hide stocks; but harvests that are threshed by machines can be checked at the threshing and the quota demanded from the peasant can be based on this check. There is little likelihood that, in Western Europe at any rate, the peasants will have large stocks of food that are not allowed for in the official estimates.

It is also argued that Europe may be liberated in instalments and that one instalment may have raised a fresh harvest and have become partially self-sufficient before another is in a position to receive relief. This estimate of the length of the war may be correct, but it should not form the basis of our plans for relief. In any case, the great difficulty will be in meeting the demand for animal products, and no means have been suggested whereby the numbers of livestock can be restored in less than 4 or 5 years.

According to Article IV, §2, of the draft of U.N.R.R.A.:

> "Foreign voluntary relief agencies may not engage in activity in any area receiving relief from the Administration without the consent and unless subject to the regulation of the Director-General."

It may be asked, "What will be the function of such organizations in the relief scheme?" They have the merit that they show, as no Inter-Allied organization can, that there are people in other countries who care enough

for the sufferings of their fellows to face danger and privation in order to help. They can pull demoralised and disorganised people together as they have in the past. They will be most useful where government has broken down or where its arm does not reach. But they carry with them the danger that people at home will say, "While this splendid work is being done, what need is there for further help?" And in the nature of things, relief that depends on private charity never does more than mitigate the extreme suffering; for the majority of people will give little or nothing until they are shown pictures of ricketty babies, starving children, and dead mothers. While, to-day, we are so inured to horrors that these horrors even may no longer bring the response that came in the years after 1918.

Although the amounts of food sent as relief to Europe from 1918 to 1923 were large in comparison with what can be provided by private charity, they do not look so impressive when compared with the amounts eaten in more fortunate countries. The total amount of food furnished as relief from 11 Nov. 1918 to July 1923 was less than the wheat and flour, meat, bacon and sugar imported by the United Kingdom in 1918, when imports were cut to a minimum. The amount of milk (evaporated and condensed) supplied as relief was 154,000 tons; the United Kingdom imported 128,000 tons of evaporated milk in 1918, when the milk supply of the country was reduced by only about 25%. Before the war Great Britain imported about 80,000 tons of condensed milk per year, and imports at present must be of the same order. All the pork products furnished as relief during the whole period was equal to one-tenth of the amount consumed in the U.S.A. in 1919. It would be possible to build up stocks of non-perishable animal products beforehand and add appreciably to the supply of semi-perishable foods during the relief period by stricter rationing in Britain and the U.S.A. now and continuation of rationing when fighting is over. The result would, at least, be an improvement this on the last occasion. We should be ready to make sacrifice for people whose need will be far greater than ours.

The powers of the Director-General, who is to be the executive authority of U.N.R.R.A., are laid down in Article IV, §2 of the Draft:

> "The Director-General shall have full power and authority for carrying out relief operations contemplated by Article I, §2(a), within the limits of available resources and the broad policies determined by the Council or its Central Committee. Immediately upon taking office he shall in conjunction with the military and other appropriate authorities of the United Nations prepare plans for the emergency relief of the civilian population in any area occupied by the armed forces of any of the United Nations, arrange for the procurement and assembly of the necessary supplies...."

This is excellent so far as it goes. But, the Director appears to have no power to increase reserves of food by stimulating production or limiting consumption, now or in the future. He cannot override the Combined Food Board. In fact it has been stated: "that U.S. War Food Administration has notified the Office of Foreign Relief and Rehabilitation that food reserves asked for by the Relief Agency cannot be set aside without cutting civilian consumption and allocation to Great Britain and Russia, and the War Food Administration does not propose to cut down any of the three."

It is commonly supposed that all the supplies needed for relief and reconstruction will come from a bottomless reservoir in the U.S.A., and that therefore the whole organization of the production and distribution can be left to the Americans. Before the war, Canada, Australia and Argentina exported more food than did the U.S.A. Argentina should be better able than any other country to expand the production of food, as the farm workers are not drained away to fighting services and munition factories. Actually, as planned by the Inter-Allied Post-War Requirements Bureau, a small fraction only of these supplies should come from the U.S.A. two-thirds should be supplied by European countries when once the wheels of production and trade are set going again.

Article V, §3 of the draft agreement of U.N.R.R.A. states:

> "All purchases *by any of the member governments* to be made outside their own territories *during the war for relief and rehabilitation* purposes, shall be carried out through the appropriate United Nations agency."

However, although Great Britain and the United States are signatories of the agreement, goods for use in these countries would not count as "purchases for relief or rehabilitation"; they will, in spite of this proviso, be able to buy up supplies independently. A central body is needed over and above U.N.R.R.A. that will ration supplies between all the governments that are willing to co-operate, besides deciding between the claims of the various Combined Boards, not only for food but for the other goods and services needed for the programme of Relief and Reconstruction.

Shipping should not be so scarce at the end of this as at the end of the last war. But the transport of supplies will again be held up for lack of tonnage if shipping is decontrolled, particularly if private traders in Great Britain, the U.S.A. and Canada are free to purchase abroad. Inland transport in Europe will be even more disorganized than in 1919, when it was necessary to place a pool of rolling stock at the disposal of the Director-General of Relief. The International body must therefore have the control of shipping and rolling stock that will ensure for U.N.R.R.A. the transport it will need.

Finance

The terms of the Lease-Lend agreement are a sign of the realization that interest and principle can bere paid only in goods which embarrass the creditor and the debtor can ill spare.

Up to the end of 1918 Britain, France and Italy had been asking the U.S.A. to supply as much food as the shipping allowed for the purpose could carry. After the Armistice this demand dropped suddenly as shipping was freed to travel to more distant ports. Farmers in the U.S.A., who had been producing hogs and wheat up to the limit, for guaranteed prices, looked like being left with enormous stocks on their hands. They were saved from a slump by the purchase of these stocks for relief. It is no discredit to the U.S.A. that the operations of the American Relief Administration were not wholly altruistic. At the Peace Conference the representative of every country, to use

Clemenceau's phrase, "Talked like President Wilson, but acted like Lloyd George."

The purchase for relief did benefit two sets of people, the recipients and the American farmers, and it harmed no one. Most of the food was supplied on credit; but according to the estimates of the Economic, Financial and Transit Department of the League of Nations only 10% of the debt was repaid. Much trouble would have been spared if the relief had been given outright. In the end the expense was borne by the American tax-payer; but the cost to him was much less than it would have been if the farmers had been left with stocks on their hands, as they were ten years later; the benefit was mutual. Might not this be a precedent for a new form of economy, whereby surplus goods will be transferred from those who do not want them to those who do, without the formality of chalking up a debt? We are now familiar with the process of giving Germans large consignments of expensive goods, day and night, without thinking of making out a bill, because we believe that this gift will further the ultimate good of the world. Can we not equally give to Belgians and Poles, Czechs, French and others, goods that they need for establishing a common prosperity? Capital would be better lost in this way than in establishing factories in the U.S.A. to make goods in excess of consumer's purchasing power, or in financing Krupp and Mannesmann in making munitions to kill Americans.

A Supreme Economic Council

There is, therefore, an urgent need for a body, comparable to the Supreme Economic Council that was set up in 1919. Such a body could give the firm orders for food, without which farmers will not risk an increase of their crops and livestock. It could decide between the rival claims of the combined Boards; and, after the war, it could allocate transport, capital and goods between the various international activities and approve the demands of individual nations not on relief. If such a Council enables U.N.R.R.A. to carry out a programme along the lines proposed by the Inter-Allied Post-War Requirements Bureau, we shall have, in being, the machinery needed to carry us to the goal set up by the Hot Springs Conference and shall have started on the road towards that goal.

The latest news of U.N.R.R.A. makes the need for a Council more urgent. It is now admitted that stocks are insufficient, and that Relief will have to be restricted to the bare minimum necessary to keep Europe alive. Yet no method of increasing stocks at this eleventh hour is suggested, although the Department of Agriculture of the U.S.A. has stated that American people are still *wasting* enough food to feed 20 million people for a whole year. Argentina, the country best able to increase food production, is not represented on U.N.R.R.A. The Combined Food Board still plans policy; it is composed of representatives of the U.S.A. and Britain. The Combined Raw Materials Board (U.S.A. and Britain) allocates strategic materials. The Combined Production and Resources Board (U.S.A., Britain and Canada) combines war production programmes. U.N.R.R.A. must depend on these Boards for its supplies. The revival of Europe will not be planned by a body representing all the nations interested but will depend on the charity of these Anglo-American Boards.

Hot Springs

The goal considered by the United Nations Conference that sat at Hot Springs, Virginia, from 18th May to 3rd June, 1943, was "*Freedom from want in relation to food and agriculture*"—the "Freedom from want Economy" discussed in DISCOVERY for July, 1943. The delegates of 44 nations, who attended the conference, included statesmen, economists, and experts on agriculture and nutrition. They estimated the deficiency in the supply of food throughout the world and the volume of ill-health and inefficiency caused by this deficiency; they set up definite standards of Freedom from Want and specified the changes in agriculture needed in order to attain this standard.

Much of the preparatory work was done by the League of Nations. Their work did much to spread a realization of the need and the possibility of better nutrition throughout the world; it effected some local improvements; but it failed to check the drive toward a restrictive economy, autarky and war. The League failed primarily because it had no powers, but it also did not recognize how little can be done by the individual efforts of any country. The Hot Springs Conference took as one of its premises that Freedom from Want is difficult to achieve without concerted action among all like-minded nations; it recognized also the need for special international measures to promote wider food distribution between nations.

The conference enumerated various measures which would be necessary in order to bring the world's food supply up to the level demanded by the standard of Freedom from Want and to enable consumers to purchase the growing supply. The measures designed to provide more food, include changes in farming systems, irrigation, supply of agricultural credits, emigration and establishment of new industries to relieve rural overcrowding. Even these measures could be planned and carried out only by an international authority with executive powers. But the production and distribution of food cannot be considered apart from other forms of production and trade. To improve their methods farmers need manufactures and they exchange their produce for manufactures. It will prove impossible to increase the consumer's power of purchasing food without increasing his power to purchase other goods as well. The recommendations of the Hot Springs Conference, with these implicit changes, amount to a programme for a world-wide expanding consumers' economy with the pace set by food. Without a world authority with powers to correlate and control production and consumption, any such economy would degenerate into a chaos of over-production and competition. Such an authority will involve a surrender of national sovereignty. It is not conceivable that states, as we know them, will come together formally to abandon their sovereignty; but they will combine to attain any object which is urgent, obvious, and mutually advantageous. If U.N.R.R.A. attains the powers necessary to reach its objectives, and if it succeeds in a programme such as that put forward by the Inter-Allied Post-War Requirements Bureau, this combination will have been achieved. We shall have, in being and working, a World Government that can go on towards Freedom from Want.

The Night Sky in January

M. DAVIDSON, D.Sc., F.R.A.S.

The Moon.—Full moon occurs on January 10d. 10h. 09m., U.T. and new moon on January 25d. 15h. 24m. The following conjunctions take place:

Jan.					
6d. 18h.	Mars in conjunction with the moon			Mars	8° N.
8d. 04h.	Saturn	,,	,,	Saturn	2 N.
13d. 11h.	Jupiter	,,	,,	Jupiter	0·7 S.
22d. 21h.	Venus	,,	,,	Venus	2 S.
22d. 23h.	Mercury	,,	,,	Mercury	0·1 S.

Occultations.—The following occultations of stars brighter than magnitude 6 take place, the times referring to Greenwich:

					a	*b*
Jan. 4d.	16h. 14·6m.	ξ^2	Ceti	D	−0·4m.	+2·4m.
8d.	19h. 31·8m.	64	Orio	D	−0·9m.	+1·4m.
9d.	00h. 52·5m.	68	Orio	D	−1·3m.	−2·1m.
15d.	04h. 15·1m.	308B	Leon	R	−0·9m.	−2·3m.
16d.	05h. 03·9m.	*b*	Virg	R	−1·9m.	−0·3m.

(D and R mean disappearance and reappearance, respectively).

The Planets.—Mercury is in inferior conjunction on January 8, and is not well placed for observation in the early part of the month. In the middle of January the planet rises about an hour before the sun and also sets an hour before the sun. At the end of the month the times of rising and setting are 6h. 27m. and 14h. 29m. respectively. Venus is a morning star rising at 4h. 37m., 5h. 12m., and 5h. 44m. at the beginning, middle and end of the month respectively. The planet can be observed up to the early afternoon as she does not set until about 13h. 30m. during January. Mars, in the constellation of Taurus, is stationary on January 10. The planet can be seen through the greater part of the night, being due south at 21h. 30m., 20h. 34m., and 19h. 42m. at the beginning, middle and end of the month respectively, and setting at 5h. 45m., 4h. 50m., and 4h. on the corresponding dates. On January 1 Mars is over 60 million miles from the earth and at the end of the month the distance has increased to 82 million miles. Jupiter, in the constellation of Leo, can be seen in the late morning hours, rising at 7h. 15m. in the middle of the month—more than three-quarters of an hour before the sun. The planet is best seen in the early evening, the times of setting at the beginning, middle and end of the month being 10h. 29m., 9h. 32m., and 8h. 28m. At the beginning of the month Jupiter is 430 million miles from the earth and the distance decreases to 408 million miles at the end of the month. Saturn is near Mars and sets about an hour later than Mars at the beginning and middle of the month. On January 31 the planet sets at 4h. 39m. Saturn is 753 million miles from the earth at the beginning of the month and 778 million miles away at the end of the month. The earth makes its closest approach to the sun on January 4, its distance then being 91,446,000 miles.

Times of rising and setting of the sun and moon are given below, the latitude of Greenwich being assumed:

Jan.	Sunrise	Sunset	Moonrise	Moonset
1	8h. 06m.	16h. 00m.	11h. 04m.	21h. 41m.
15	8h. 01m.	16h. 18m.	21h. 38m.	10h. 27m.
31	7h. 42m.	16h. 46m.	10h. 48m.	0h. 41m.

Eclipse of the Sun.—There will be a total eclipse of the sun on January 25, partly visible as a partial eclipse at Greenwich. The eclipse begins at Greenwich on January 25d. 16h. 29m.; it begins 4 minutes later at Oxford and 2 minutes later at Plymouth. It will not be a spectacular eclipse as only 1/50th of the sun's disc will be eclipsed at Greenwich, and this occurs just before sunset.

Some interesting objects can be seen in the constellation Gemini. α Geminorum is the second brightest star in the constellation (an inversion of the usual order, as the brightest star of a constellation is generally denoted by α). This star, known also as Castor, is a beautiful double, the magnitudes of the components being 2·7 and 3·7, and can be divided with a small telescope as the components are 6″ apart. The period of revolution round their common centre of gravity is about 1,000 years. It is believed that Castor has decreased in brightness since the stars received their Greek letters in 1603. Amongst other doubles may be noticed δ whose companion, magnitude 8, is at a distance of 7″ and is of a reddish colour; ε with a companion of magnitude 9 at a distance of 111″; μ with a rather faint companion, magnitude 9·5, at a distance of 122″. ζ is an interesting star with a deep yellow colour, and varies by nearly a magnitude in just over 10 days. It has two companions, one of magnitude 7 at a distance 94″ and therefore easily seen with quite a small telescope; the other of magnitude 10·5 at a distance 87′, a more difficult object to find. Two beautiful star clusters in the constellation should be observed. The first contains stars of magnitudes 7 to 11 which are coarsely scattered, and some of which can be easily seen with a small instrument. Its position is R.A. 5h. 55m., Dec., + 23° 18′. The other cluster is not easily seen, as the brightest stars in it are of magnitude 9. Its position is R.A. 6h. 3m., Dec. + 24° 21′. They can be located by noticing that the star η which varies in magnitude from 3·2 to 4 in 231 days, is at R.A. 6h. 9m., Dec. + 22° 32′, and a few minutes sweeping with the telescope will enable them to be found.

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FIG. 1.—New pot culture houses at Rothamsted

Crop Growth and Plant Nutrition

SIR E. JOHN RUSSELL, D.Sc., F.R.S.

UNTIL recent years the study of the growth of plants developed rather erratically. There were always men interested in their gardens and prepared to meditate on the nature of soil and on the way that plants grow: indeed picturesque speculations on the subject are not unknown even to-day. But it was the Swiss botanist de Saussure who introduced quantitative methods for studying plant growth at the end of the 18th century, and the French chemist Boussingault who first applied them in agriculture. In 1834 he married the daughter of an Alsatian landowner, settled down on the estate, and forthwith began to make a balance sheet of the rotation. He analysed the crops and the manures over the five-course rotation, and showed that the crops contained much more carbon, hydrogen, and oxygen than was supplied in the manure, somewhere about the same amount of nitrogen, but less mineral matter. While, therefore, the crops might have derived their nitrogen and mineral matter from the manure or the soil they could not have obtained from either their carbon, hydrogen, or oxygen; these must have come from other sources.

The quantitative method was developed from 1843 onwards by Lawes and Gilbert, who dealt specially with the source of nitrogen. They had shown by field experiments that crops gave increases running parallel with the quantity of nitrogen in the manure; and that without added nitrogen crops were small, even in some cases negligible. The facts seemed plain enough. But the men of the 19th century dearly loved a fight, and Lawes and Gilbert on the one side, and Liebig on the other, contrived to run a controversy for years as to whether plants did or did not obtain their nitrogen from the soil. It was a time when men said exactly what they thought of each other, and Liebig thought very little of Lawes and Gilbert and still less of their experiments; here for example are some of his comments:—

> "I do not doubt that you have read the new attack of Mr. Lawes and Gilbert against me, in the last number of the *Journal of the Royal Agricultural Society*, it is most frivolous and absurd and not worth to take any notice of it, if it was not, for a higher object. Lawes and Gilbert hitch on me like a vile vermin and I must get rid of them by all means; they destroy all my efforts to make understand the British farmer the right way of progress; it is a pity that it is so. There is a cowardice amongst the Scientific men in England, which I am unable to comprehend, and it is an offence against the public welfare that they have not the courage to take a decided part in that most degrading controversy between Science and ignorance."

Lawes and Gilbert were not backward in replying, but unfortunately for posterity the editor of the Journal refused to print their final reply so that we lack the complete record.

Between them, however, Lawes and Gilbert worked out a pretty complete picture of crop nutrition.

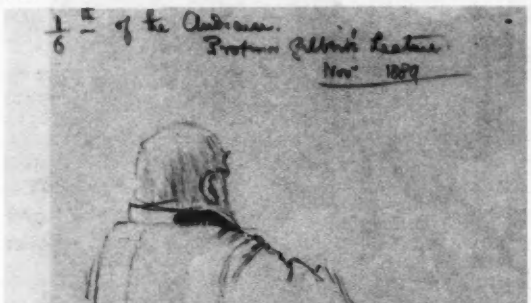

FIG. 2.—One-sixth of the audience; drawing from a student's note-book.

The two men were well fitted to work together. Lawes was the man of big ideas and clear vision, but he lacked the urge to fill out the details. His notebook shows quite clearly what he set out to do, and the very short notes indicate what results were beginning to emerge; but most of each page is empty space, apparently for observations he intended to record but never did. Gilbert, on the other hand, was intent on detail. He would have no truck with short cuts: no logarithms, no slide rules, not even the metric system. Everything was weighed in grains and ounces and measured in fractions of a gallon. His notebook is a mass of multiplication and division sums all of which are right, but it is impossible to see what they are all about.

A Sketchy Business

As a lecturer, Gilbert was not a success. He was appointed Sibthorpian Professor of Rural Economy at Oxford: this necessitated occasional visits only, as the duties were not then onerous. But his lectures were not popular, although his strikingly picturesque figure appealed to some of the more artistically minded students. Quite by accident I obtained a record of one of his visits. I was lecturing in Oxford and regretted that I had only a formal portrait of the man to show: at the close a white haired don came up and said he could give me a better one. He had known that Gilbert's lectures were very poorly attended and in the hope of improving matters had "required" one of his students to go to the next one. The instruction was obeyed, but in order to ascertain whether the man had gained anything he asked to see the note-book. At first the student demurred, but finally had to produce it: it contained little but a superb sketch of Gilbert. The tutor had, of course, to uphold University discipline and severely upbraided the man for wasting his precious opportunity: at the same time he recognised the artistic merit of the sketch—and confiscated it for his own collection. Unfortunately he had forgotten the name of the student.

By another accident, which no one would accept if he saw it on a film, I discovered almost certainly the name of the student. I was travelling in New Zealand and arrived at a very remote spot in the South Island. Somebody or other was expected to give a lecture, at the last minute he was unable to come. Would I fill the gap? As I had been speaking at some of the big Institutes I had some lantern slides with me, so I volunteered: I showed this picture and related its history, specially regretting that the artist was unknown to me. The audience numbered about a dozen people. At the end of the lecture a man came up to me and said "I know who did that picture: it was Richard Paget. There were six people at the lecture: he and I were two of them."

Directly I got back to England I showed the sketch to Sir Richard and asked if he had done it. He could not be sure. He remembered attending the lecture and spending the time in making sketches. He still had some of these. One was a member of the audience, an elderly gentleman, the back view only, but a perfect expression of boredom: it was labelled: "1/6th of the audience." Another was the beginning of a sketch of Gilbert, but he hadn't liked it so crossed it out. But there seemed no doubt that my sketch was by the same hand, and he would certainly have known if an equally competent artist was among the remaining three members of the audience.

Early Research on Crop Nutrition

Lawes and Gilbert never advised on the details of farming: their work was to ascertain the fundamental facts of crop nutrition, but to leave the applications to others. There were at that time no local organisations to help farmers, but the Royal Agricultural College at Cirencester and the Royal Agricultural Society in London both undertook educational and advisory work. A young chemist, Augustus Voelcker, who in 1847 migrated to this country from Germany, was on the staff of both, and he made field experiments on farms in different parts of the country, testing various combinations of fertilisers and gradually working out recipes suited to different soils and conditions. He analysed the soils and acquired considerable knowledge of the relation of soil composition to fertiliser action: much of it was empirical, but it worked, and farmers looked to him for guidance. His son John Augustus Voelcker kept up the tradition.

Later on an extensive advisory service was developed, which now covers the whole country. It was intended that this should work closely in association with the research Institutes, but actually the staffs have been so fully occupied that they have not been able to co-operate as closely as either would have liked: the research men could not break off important investigations to make the necessary long journeys involved, nor could the advisors

leave their farm clients at critical times for several days at a spell in order to visit research Institutes. This problem is not yet solved. It is, of course, not peculiar to agriculture; applied science always lags behind pure science: a distinguished engineer recently stated that the physics of engineering was the physics of 50 years ago, not of to-day. In agriculture the time lag is perhaps less because the progress of agricultural science is slower than that of physics.

For some 40 years after Rothamsted started the only science concerned with soil and plant nutrition was chemistry; the older readers of the *Journal of the Chemical Society* will remember that agriculture used to be included in the Abstracts. But from about 1880 onwards two other subjects came in. The German physicist Wollny saw the possibilities of studying the physical properties of soil, especially those included under what used to be called "Properties of Matter." The great advances, however, were made in the United States, where the pioneers included Hilgard of California, F. H. King of Madison, and Milton Whitney of the Department at Washington. In the Western States the main problem was water supply; fertilisers were not usually needed. Rain was sparce and soil moisture had to be conserved; farmers had to be advised how this could be done. They had learned empirically the value of a fine mulch, and the scientific workers, starting out from this fact, and from the ideas on capillarity current at the time, built up a hypothesis in regard to movements and conservation of moisture in the soil which they proceeded to use in their further investigations and in their advisory work in the semi-arid regions. Unfortunately it appeared later that the problem should have been approached further back. It is one of the pitfalls of agricultural science that the apparently direct approach is frequently not the right one. Events showed that the advice to mulch constantly, which was based on the old capillary hypothesis, was quite wrong; the frequent discing to secure the mulch broke the soil down to a fine powder which easily blew or got washed away and so led to soil erosion which caused such havoc in the Middle West of North America. No blame attaches to the pioneers, but we should be held greatly to blame if we neglected the bitter lessons of experience.

The investigation ought to have begun with the structure of the soil: the study of the grains that are so characteristic a feature of the good black earth of the prairies, and of the agencies that build them up and break them down; generally the study of the powder into which they fell. This was done later, and it was shown that the prairie soil remains stable only so long as it preserves its crumb structure; that this can best be brought about be leaving the land for a time under grass or clover or the mixed herbage called "sod." The advice should have been to alternate arable and grass or sod husbandry. We are wise after this particular series of events, but we are probably making equally serious mistakes through trying short cuts elsewhere.

New Methods of Investigation

Another direction in which plant nutrition studies developed was into microbiology. The miracle whereby the dead remains of one generation of plants becomes the

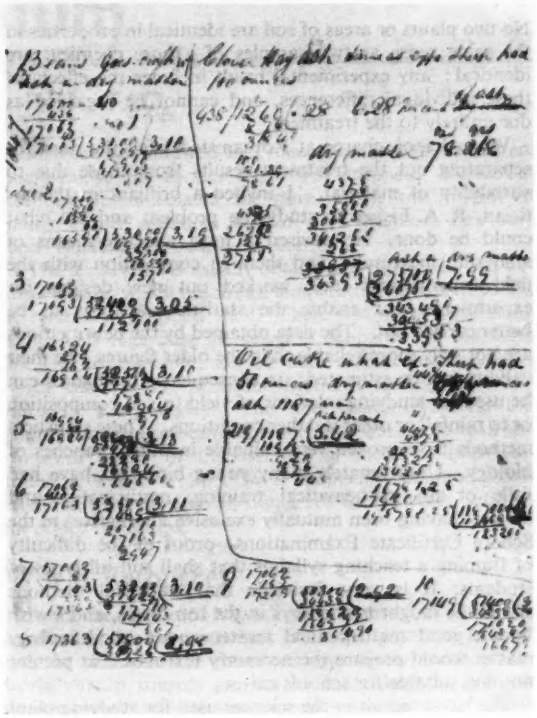

FIG. 3.—Page from Gilbert's note-book.

life food for the next generation, thus completing the cycle of death and life, has been a never ending source of wonder to all thinking people. The process is brought about by the innumerable micro-organisms in the soil, which for their own sustenance and energy requirements attack the dead plant materials and resolve them into simple substances devoid of easily obtainable energy but capable of feeding plants. At first the different groups were studied in isolation; then it was realised that they must be studied in their relations to one another, and this is now being done. The subject is very intricate: the numbers of the different organisms are not only large but they constantly fluctuate and the equilibrium between them is obviously extremely mobile. There are profound antipathies between some organisms and others, bacteriophages occur in the soil, and complex relationships exist between leguminous plants and the organisms especially associated with them. Steady progress is being made by H. G. Thornton and others working in this field, but so far applications to practice have been made in only three directions: partial sterilisation of soil, now widely used in glasshouse practice; the making of compost for manure, much practiced by market-gardeners and other horticulturists; and the inoculation of lucerne seed before sowing, now almost invariably done by seedsmen before it is sent out.

Up to about 1920 the study of crop nutrition had been quantitative only to a very limited extent. A vast array of data had been assembled, and great care had been taken about every individual figure, but there was always uncertainty due to the variability of plants and of soils.

No two plants or areas of soil are identical in properties in the same sense as two samples of a pure chemical are identical; any experimental result includes the effects of these individual differences, and cannot be regarded as due entirely to the treatment.

When I took charge at Rothamsted I felt the need for separating out the treatment results from those due to variability of material. I invited a brilliant mathematician, R. A. Fisher, to study the problem and see what could be done. He devised a most effective means of analysing the results, and then, in conjunction with the field experimental staff, worked out new designs for experiments that enable the statistical analysis to be better carried out. The data obtained by the new methods are not only more reliable than the older figures, but their validity can be estimated: in consequence the figures can be used for studying relations of yield to soil composition or to rainfall or other weather conditions. These statistical methods have proved very valuable in other branches of biology. Unfortunately many young biologists have had little or no mathematical training, mathematics and biology having been mutually exclusive alternatives in the School Certificate Examinations—proof of the difficulty of framing a teaching syllabus that shall suit all types of students. It is very desirable that statistical methods should be taught to the boys in the top forms, and I wish that a good mathematical master and a good biology master would prepare the necessary textbook: at present nothing suitable for schools exists.

The latest recruit in the sciences used for studying plant nutrition is biochemistry. It is now realised that the plant is very much the product of its food, and by varying the foods supplied its composition can be changed fairly considerably, especially in the green parts: the grain is not easily altered by feeding though it is much affected by variations in the water supply during its growth. This change in composition affects not only the quality of the crop as judged by the expert buyer, but also the reaction to disease organisms, and insofar as it alters the rate of growth of the plants, it influences their reaction to insect pests.

Biochemists have already found in the plant-cells substances that direct the growth processes. These are relatively simple bodies: phenyl- or napthyl- acetic acids; and they have a marked effect in inducing root action: they are already used by horticulturists for the striking of cuttings. This work began at Utrecht and is now being taken up here.

Perhaps the most remarkable of the plant nutrients are those needed in very small amounts only: manganese, boron, copper, zinc, and others. They were discovered at the Pasteur Institute by Mazé and by Gabriel Bertrand, but no one accepted the results: Bertrand once told me he had been refused permission to read his paper at a Conference. The case for boron was definitely established at Rothamsted by Katherine Warington. Davidson the entomologist had been trying to make the bean crop distasteful to aphids and he had fed the plants with all kinds of things he thought the insects would dislike, but without result. Among his many substances was borax, and while this did not affect the aphis it did increase the growth of the beans. Dr. Warington took the matter up, and found that the beans would not grow without a little boron, though one-part in one-million of the culture solution sufficed.

We are, however, by no means at the end of the story. Thornton has shown that young leguminous plants excrete into the soil something which causes the nodule bacteria in their immediate vicinity to multiply vigorously: the bacteria then proceed to excrete something that curls the root hairs, straining them at the bend, so that the bacteria are able to enter. Williams has now shown that wireworms are very adversely affected by the growth of broad beans; presumably some excretion is fatal to them. It looks as if plants have some power of self-protection by means of excretions though what these may be remains to be seen. Fortunately Professor Todd of Manchester is investigating an allied subject and may be able to work out the chemistry of the process.

The study in this country of the chemistry of crop growth began in the barn at Rothamsted as it had begun earlier in Alsace in an outhouse on Boussingault's farm. The pioneers made great progress with rough appliances and crude methods: the nuggets lay on the surface waiting to be picked up. The later stages, however, require much more refined methods and more delicate apparatus; the decimal points now become supremely important and the figures have to be as nearly accurate as possible. That is the difference between the early and later stages in the advance of science, but it is also the difference between research and advisory work, and between science and technology. The adviser and the technologist can both go a long way with crude methods and can give an answer that works for a time, though, of course, they do better with more refined methods. The scientist cannot accept any except the best methods and the most effective appliances, and he must push on to the most accurate results he can possibly obtain. Only in this way can he be sure of gaining true knowledge, and without this the adviser is sadly hampered in his work and may even be giving wrong advice. Both kinds of work are necessary but they can rarely be combined, for the good research man is not usually a good adviser nor is the successful advisor usually an effective research man.

MOULDS AND COLDS

THE discovery of a new drug derived from a mould of the Penicillium genus and its efficacy as a cure for the common cold is described in *The Lancet*, 1943, **245**, 6273, p. 625. The drug is called patulin, a name derived from the specific name of the mould—*Penicillium patulum*—that produces this queer by-product in its metabolism. Patulin, which is considered to be anhydro - 3 - hydroxmethylene - tetrahydro - γ - pyrone - 2 - carboxylic acid, has a strong bacteriostatic action, inhibiting the growth of *Staphylococcus aureus* at dilutions of 1 in 64,000. It is about equally bacteriostatic to both gram-positive and gram-negative organisms; it is however less active than penicillin against gram-positive organisms, but much more so against gram-negative ones. It has been obtained pure, as a colourless crystalline substance with a melting point of 111°C., and empirical formula of $C_7H_6O_4$. Preliminary trials of this drug in the treatment of colds show that 57% of the colds were cured in 48 hours as compared with 9·4% recovery in "controls" who received no dose. Patulin will not be released however for general issue until further large-scale confirmatory trials have been completed. The material for these trials is being supplied by the Therapeutic Research Corporation of Great Britain under the brand name of "Tercinin."

Titanium

J. CHATT, M.A., Ph.D., F.I.C.

THE so-called rare element titanium has recently received some publicity on account of an alleged cartel agreement exposed in the U.S. courts, whereby, amongst other things some of the largest chemical firms of the world are said to have agreed amongst themselves regarding the control of its sources and supply. Very few people will have heard of titanium, and indeed many—one may even say most—chemists, if they were asked off hand what use was made of titanium, would be able to give very little information.

Titanium is a metal, but pure titanium is almost a chemical curiosity. It is one of the most difficult of metals to obtain pure from its ores, for the ample reason that it combines or alloys with most other elements.

Far from being a rare element, titanium is amongst the nine most common chemical elements in the earth's crust; of the well-known metals only aluminium and iron exceed it in abundance. It is more abundant than sulphur, carbon and chlorine, and the world's estimated available supply is over four times that of chromium, copper, lead, manganese, mercury, nickel, tin, and zinc together. It is surprising therefore that titaniun is not better known, but probably this is due to the fact that major uses for this element have been found only comparatively recently and that they are not spectacular or obviously unique ones. Actually titanium metal is in much the position to-day that aluminium metal was about half a century ago.

Discovered in Cornwall

Titanium was discovered by the Rev. William Gregor of Creed, Cornwall, who analysed some black magnetic grains found in the sand of a brook in the Cornish parish of Manaccan. He inferred from their properties that they contained a new metal which he proposed to call menaccine, and an account of his discovery appeared in Crell's *Annalen* in 1791. The sand he named menaccanite, but the mineral is now generally known as ilmenite, because one of its principal European occurrences is in the Ilmen Mountains in the Urals. A few years after its discovery, M. H. Klaproth, whilst studying other minerals, found evidence of a new metal, which he named titanium in allusion to the Titans as the first sons of earth. Later (1797) Klaproth analysed the black sand from Manaccan and showed that menaccine and titanium were identical, so the former name was dropped. Neither of the discoverers isolated the pure metal, and in spite of many earlier attempts almost pure titanium has only been isolated comparatively recently.

The metal itself is usually obtained as a grey powder, but after fusion, which requires a temperature of over 1800° C., it resembles polished steel. There are many conflicting statements regarding the physical properties of titanium, for whilst some experimenters found it to be ductile, others —for example H. Moissan—found it to be sufficiently hard to scratch glass. The uncertainty regarding the properties of pure titanium is certainly bound up with the doubtful purity of the samples of metal obtained by different workers. In 1936 a chemical catalogue listed titanium metal at 10s. an ounce for the powder, but 53s. an ounce for lumps.

World Resources

It may be wondered how all the sources of so abundant an element can be controlled, but large quantities of ores rich in titanium are found comparatively rarely. The world's main sources are the minerals ilmenite (ferrous titanate) and rutile (almost pure titanium dioxide). They are usually obtained commercially from sands rich in the black grains or pebbles of these and other minerals, which are separated from the sand by washing away the lighter particles. Ilmenite is magnetic, and this property is used to separate it from rutile and the associated minerals (see Fig. 1), whilst the latter may be separated by flotation.

Ilmenite was the source of about 99% of the titanium used before the war and about three-quarters of this came from the beaches of Travancore in South-west India. It is also obtained in Norway, Sweden, Portugal, Canada South Australia, Malaya and Senegal. The United States and Russia use all their production internally, and in addition the United States imports most of the world's remaining production. Rutile is found in commercial deposits in these countries and also there is an extensive deposit in Brazil.

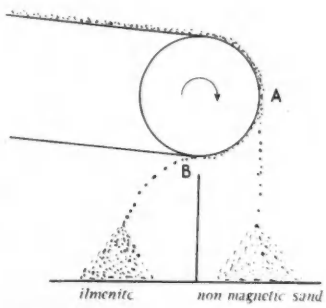

FIG. 1.—Diagram showing the Principle of Magnetic Separation. The sand is carried on a belt over a magnetised roller. The non-magnetic sand falls off the belt at A, but the highly magnetic grains are held on by the magnetic attraction of the roller until they are carried out of the magnetic field at B, then they fall away from the belt.

Titanium compounds and alloys are increasing in importance very rapidly. Russia and the United States do not publish their production figures, but production of ilmenite in the rest of the world has risen from 43,600 tons in 1931 to 264,000 tons in 1937. Of this latter quantity 26,369 tons

FIG. 3.—Titanium tetrachloride is a strongly fuming liquid. This smoke was produced by scattering 4 ozs. of it on the ground shown at the right hand side of the photograph.

were imported into the United Kingdom. In 1938 Travancore alone produced 252,220 tons, but the United Kingdom's total imports were only 16,784 tons.

Besides the rich ores, titanium is found in many minerals and most soils and clays contain it to the extent of about ½%: from this source it is absorbed by plants and thence finds its way into the flesh and bone of all animals. After aluminium has been removed from its ores, the residues sometimes contain sufficient titanium to make its extraction an economic proposition.

Valuable as an Alloy

It is not the pure metal which is valuable, but its alloys with iron known as "ferrotitanium." These are obtained by the reduction of ilmenite with carbon, or, if a carbon free alloy is required, with aluminium in an electric furnace containing molten steel. The value of the alloys lies in the remarkable affinity of titanium for nitrogen and oxygen. When the correct quantity of ferrotitanium (e.g. 2 to 20-lb. a ton of steel) is added to the molten steel containing these harmful impurities they are removed by combination with the titanium, and in addition the slag separates more readily from the steel.

If more titanium is added than is required for cleansing the steel, the excess remains alloyed with the iron, conferring on the steel greater strength and resistance to abrasion. Such steels are recommended for propellor shafts and driving rods.

Alloys of titanium containing no iron are also made for similar use to ferrotitanium in the manufacture of non-ferrous alloys, and very often a little titanium increases the strength of the alloy. All aluminium alloys are said to be improved by small amounts of titanium.

Useful Compounds

Titanium dioxide is by far the most important compound of titanium. Rutile, the common naturally occurring dioxide, is very resistant to chemical attack and hence difficult to purify. It is employed in electric welding as a coating for welding rods, where it promotes a smooth steady arc and hence a uniform weld, in addition to forming a protective coating of slag on the weld.

Pure dioxide is obtained from ilmenite as a white powder (anatase) of very high refractive index, which gives it its most important use as a pigment known as titanium white, which is used in paints, enamels, lacquers and glazes. It has better covering properties than other pigments, and whilst 1-lb. of white lead covers 20-sq. ft., the same weight of titanium dioxide covers 109-sq. ft., which in spite of its greater cost makes it one of the cheapest paints in use. In addition it has the advantage of being non-poisonous and is not blackened by traces of hydrogen sulphide in the air.

The great opacity of the dioxide is turned to good use in paper-making, where its incorporation makes it possible to obtain a very thin paper sufficiently opaque to prevent printers' ink showing through. Titanium waxed paper is so opaque it does not show grease spots. The use of the dioxide in rayon removes the undesirable lustre shown by the untreated product, and a high degree of opacity and light colours are obtained by its incorporation in rubber, linoleum, plastics, leather, soap, face powders, face creams, and in tooth pastes and nail polishes, where its slight abrasive action is also useful.

Together with the high refractive index goes an exceptionally high dielectric constant and low dielectric loss, i.e. loss of electrical energy in the form of heat developed in the insulators of a circuit carrying high frequency currents as employed in wireless telegraphy. Insulators of simple shape have already been made from rutile, and magnesium titanate is employed as the dielectric in high frequency condensers.

In the textile industry titanium compounds find important uses as mordants, to make the dye stick to the fabric, and also in the mordanting and staining of leather. Potassium titanium oxalate stains leather to various shades of brown and produces a less brittle product than when iron salts are used for the same purpose. Titanium trichloride, and titanous salts generally, are very strong reducing agents, and are important as stripping agents to remove the dye from material which has to be re-dyed.

The above includes the most important peace-time uses of titanium, but in addition there is an important war-time use. Titanium tetrachloride is a strongly fuming liquid which is obtained by the direct action of chlorine on rutile intimately mixed with carbon (see Fig. 2). It was found to be one of the most successful producers of smoke screens, and in 1918 160 tons of ore were used for the production of titanium tetrachloride. It is used to best advantage with ammonia in a damp atmosphere.

The uses of titanium are by no means exhausted, and it is to be expected that future research will show important ways in which this abundant but unfamiliar substance can be turned to the use of mankind.

The Bookshelf

Outlines of Entomology. By A. D. Imms, D.Sc., F.R.S. (Methuen and Co., 1942; pp. i-viii + 1-184 + 96 illus.; 12s. 6d.)

Entomological research, research workers, and advanced students have long been deeply indebted to Dr. A. D. Imms, and now with the appearance of this book the debt is extended to the elementary student. In the preface the author informs us that the book is intended to introduce entomology as a branch of general zoology, and in accordance with this we find the factual matter carefully selected, brought up to date, and presented in a manner rather different from the author's earlier *General Textbook of Entomology*. Many elementary students will find rather too much for their requirements, but this can scarcely be regarded as a disadvantage. In the less ambitious textbooks of zoology considerations of space often prevent the insects from being adequately treated and the *Outlines of Entomology* will prove an invaluable supplement to such books.

Attached to certain chapters are appendices on such topics as social insects, insect coloration, aquatic insects, predatism, and parasitism. Coloration is considered in relation to the Lepidoptera (butterflies, etc.), social insects in relation to the Hymenoptera (ants, bees, wasps, etc.), phases in locusts to the Orthoptera, and so on. This not only emphasises a leading biological characteristic of the group concerned, but reveals the value of a thorough training in morphology as an introduction to the more elusive problems of entomology. The brevity of the treatment of each topic does not detract from its interest and in every case a firm foundation for wider reading is provided.

H. H.

Dictionary of the Fungi. By G. C. Ainsworth, B.Sc., Ph.D., and G. R. Bisby, M.A., Ph.D. (Imperial Mycological Institute, 1942; pp. viii + 360 + 20 pp. of figs.; 20s.).

As Professor F. T. Brooks remarked in his Presidential Address to the British Mycological Society in 1922: "The fungi are a remarkable group of organisms of which we, as mycologists, are rightly proud." A handsome monument to the proper pride thus felt by mycologists has been erected by Drs. Ainsworth and Bisby in this compact volume. Its monumental character apart, this book will undoubtedly fulfil the hope of Dr. S. P. Wiltshire, who has contributed a Foreword, by providing mycologists with a really useful tool.

As the authors tell us in their Preface, they have attempted to list all the generic names of fungi in use to the end of 1939, and thus provide mycologists with a reference book of the sort that has long been available to botanists in the shape of Willis's *Dictionary of the Flowering Plants and Ferns*. Some idea of the scope of this undertaking may be gathered from the fact that the Dictionary includes some 7,000 generic names of fungi, of which about half are listed as synonyms. For every genus, a systematic position has been given, together with the distribution and number of its species.

Invaluable as such a comprehensive list of fungal genera will be to all working mycologists, the Dictionary also includes a number of other useful features, such as a glossary of words used in mycology, the common and scientific names of important fungi, and the names of important fungal diseases of plants. In addition, there are notes and brief articles on topics of general interest to mycologists; particularly useful to those who are not professional systematists will be the short article on nomenclature. And lastly, to many mycologists the book will furnish the ideal pocket companion from which interesting tit-bits of information may be gleaned at random during even the most fleeting moments of leisure; on p. 307, for instance, one learns that green Tunbridge ware is made from the wood of deciduous trees attacked by a green sap-stain fungus, *Chlorociboria aeruginosa*, and that Tuckahoe or Indian Bread is the sclerotia of the fungus *Poria cocos*.

Foreign mycologists will welcome the fact that the book is unobtrusively written throughout in "near Basic" English (the authors say in their preface: "the writing (but for the Appendix) has been done in Basic English, though in addition to the words from the different Basic lists and international science words, there are a small number of non-Basic words"). It only remains to say that *Dictionary of the Fungi* will be an indispensable handbook for all mycologists at its modest price of 20/- for 359 pages.

S. D. Garrett.

T.V.A. By Julian Huxley. (The Architectural Press, London, 1943; 142 p., 150 photographs; 8s. 6d.).

It is to be regretted that Dr. Huxley whets our appetite for a complete survey of Tennessee Valley Authority's work and provides us with a mere skeleton, but perhaps the demand for this book, which is likely to be enormous, will induce him to follow it up with a really comprehensive volume on the work and achievements of the T.V.A. One other criticism which can be made concerns the lay-out of the book—it is very confusing, not to say annoying—to be left suspended in mid-sentence, while anything from four to a dozen pages of photographs have to be turned over to continue reading the text.

These are trifling matters, however, compared with the substance before us. At a time when ideas about reconstruction are being so much discussed it seems hardly coincidence that a book should be published showing just how much one body has done to realise many of our "pipe-dreams." There is hardly a relevant subject which can be mentioned that has not been touched upon, from hostility to the whole project to cost, construction, soil erosion, industry, research, agriculture, architecture and housing, recreational facilities, education and so on.

"In the biological field, valuable research has been done on such diverse problems as malaria control, tuberculosis incidence, and the encouragement of fish life." One would really require to quote the entire book if justice is to be done to the important parts. It is of more than passing interest that the author mentions that research has now reached the pilot-plant stage in the extraction of aluminium from clay; perhaps the first mutter of revolution in the industry?

All aspects of the work are illustrated profusely by photographs, most of considerable interest and not a few of an exceedingly high photographic standard.

While bearing in mind the area with which the T.V.A. worked is comparable to four-fifths of Britain, it is not without point also to compare the terms of reference of the T.V.A. and the Cooper Committee, for they are nearly identical. Huxley has very ably demonstrated what magnificent results one body can achieve; dare we hope for a companion volume on a similar scheme effected by the other?

A. G. Kay.

U.S.S.R.: Her Life and Her People. By Maurice Dobb, M.A., Ph.D. (University of London Press, 1943; pp. 1-140 + maps and illus; 4s. 6d.).

This little descriptive book, as the author says in his Preface, has "a special audience in view". It is to "assist teachers in spreading a fuller knowledge of the country that is now our ally than has been usual hitherto." Within that frame, there is no doubt that this easily readable book will attain its object. And if the reader follows it up by using the short list of recommended books given at the end, then he will become *au fait* with the general story of Russia up to mid-1943.

Maurice Dobb, who lectures on economics in Cambridge University, is of course no apprentice in Russian affairs. This latest book is his fourth upon Russia and her people. In the simplest language he traces the story of the country's history from Tsarist days up to the present year. The text is reinforced with numerous pictures, maps, and diagrams that combine to present a lucid projection of the Russian scene. Much detail is naturally and obviously deliberately omitted, but the milestones along the progressive path are clearly indicated. Occasionally—as when describing the useful but oft-forgotten part the Russian Army played in Allied strategy in 1914 (p. 21) and the reaction of the Soviet people to the Anglo-French action during the Munich crises (pp. 117-18)—a strong beam of critical light throws sections of the historical landscape into relief.

The author brings to the fore the important role that planning has played in the development of the modern U.S.S.R. As an economist he stresses the application of science both to industry and agriculture, but Russian scientists themselves are left behind the stage. However, if to the list of books recommended at the end one adds, say, J. G. Crowther's *Soviet Science*, a corrective will have been made for the reader of this magazine. Workers other than in the teaching profession will profit from reading this out-line of development in the U.S.S.R.

P.V.D.

Far and Near

Synthetic Rubber in Britain

A LICENCE for the production of synthetic rubber in this country has at last been granted by the Ministry of Production. Our London Correspondent is informed by the Ministry that the company which has been granted the licence is British Celanese Ltd., which is expected to start bulk production at a north-west factory by the beginning of next summer. The raw material for the process will be coal.

International Air Transport

AT this time, when so much public attention is being drawn to the post-war planning of international air transport, an authoritative study of this subject issued by Chatham House is welcome *International Air Transport* (O.U.P., 1943, 7/6.) The first international air navigation agreement was signed by France and Germany in 1913, but it was not until six years later that the first general air convention was held. A revision of this convention took place in 1929, and further amendments were made in 1935. By the summer of 1939, 35 nations had agreed to adhere to this much-altered international agreement, but several nations remained outside the covenant. Other conferences, such as the Ibero-American Convention of 1926 and the Havana Conventions of 1928, complete the main list of world air agreements up to the war.

Air transport, like the older sea-transport, is subject to a vast amount of international regulations. One of the most prominent in the public eye is that of the claim to the rights of sovereignty of air over individual countries. There are, however, other equally important matters connected with technical organisations. This publication by Sir Osborne Mance and J. E. Wheeler gives an adequate historical résumé of position of international air transport regulations up to 1939. A coloured map gives the main air routes operated in 1938.

Cotton Research in India

THE Indian Central Cotton Committee is now spending £75,000 yearly upon research. This money is raised by the Indian cotton manufacturers and exporters in levy of two annas a bale on all cotton used in Indian mills or exported.

The Committee consists of about fifty members drawn from all interests connected with cotton from the field to the factory, including as it does representatives of the growers, agricultural officers, research workers, and manufacturers. It has its own technological laboratory, and although much of the research work on cotton in the agricultural side is carried out by means of the subsidies it gives to the Agricultural Departments in the Provinces and States, it has a very important stake in the Institute of Plant Industry at Indore, where it has its own genetics scheme, in addition to the contribution it makes to the other work on cotton carried out at the Institute.

The Committee's work has revolutionised the cotton outlook in India. Changing the output from short staple cotton to long staple cotton is no mean feat of research, planning and organisation. Twenty years ago the quantity of cotton of staple length 1 inch was nil; this year's crop is expected to be within the region of 500,000 bales. India produces 18% of the world output, as against 42% in America. The India output presents a much larger proportionate acreage under cotton than the American, and this disparity is now receiving the attention of the Committee. The work of this Committee in relation to the Imperial Council of Agriculture and the Department of Agriculture (India) is reported upon in a recent number of the *Asiatic Review*.

Triptane: the most Powerful Aviation Fuel

THE large-scale production of triptane, described as the most powerful hydrocarbon known for use in internal-combustion engines, is one of the major accomplishments of petroleum chemists in this war. Many of the details are still secret, but some idea of the great anti-knock properties of triptane can be gained from the report that no commercial engine now in existence is capable of fully utilising the power contained in the pure hydrocarbon. Chemically 2, 2, 3 trimethylbutane, it is said to be capable of producing one and a half times the power of 100-octane aviation fuel. *Chemical Industries* (1943, **53**, p. 343) states that although triptane has been known for years it has long remained a laboratory curiosity because the known methods of producing it involved either the classical but impractical Grignard reaction, or zinc dimethyl as a re-agent. To produce triptane on a laboratory scale by these processes cost as much as £750 a gallon and even within the last two years a batch of several hundred gallons made for experimental purposes cost £10 a gallon. Now a commercial process has been perfected by Dr. Vladimir N. Ipatieff and Dr. V. Haensel of the research laboratories of the Universal Oil Products Company of America, by which a 50% yield of triptane can be obtained from gaseous by-products of "cracked" petroleum oils. The catalysts required to stimulate the reactions are readily obtainable, while no special equipment or materials are required other than those regularly used in petroleum refineries. The estimated cost of the fuel is stated to be only four shillings a gallon, and the Americans anticipate that triptane will play an important part in the war against Japan where long-distance bombers will become one of the chief weapons of assault.

"Endeavour"

THE editorial columns of the October number of *Endeavour* (Vol. II No. 8; I.C.I., Ltd., London) gives a recognition of the role that the study of Sound plays in modern physics. Almost up to the last war—in spite of the arrival of the telephone and the gramophone—this branch of physics was not developed even in commercial laboratories. To-day with the advent of broadcasting and the talkie, a great deal more attention is being given to the subject.

In other pages of the October *Endeavour*, Sir George Thomson describes the principles of the Electron Microscope and its precursors H. Dingle contributes a biographical sketch of Copernicus. A very interesting article on the Forests of the Sea is contributed by F. E. Fritsch; it may come as a surprise to the lay-reader to learn of the really vast areas of some of the "forests." H. T. S. Britton writes an important article upon the Electric Determination of *p*H and describes some of its applications. The reader with leanings towards the history of science will enjoy the contribution by the American, T. L. Davis upon the Chinese Beginnings of Alchemy.

Readers who recollect J. Grant's article From Straw to Paper in the February issue of DISCOVERY will note with pleasure the first-class British paper produced from this raw material and glazed with clay from Cornwall on which this number of *Endeavour* is printed.

Commons Plea for Bolder Research

BEFORE the recess, a hundred M.P.'s of all parties tabled a motion in the House of Commons urging the Government to take bold action to encourage scientific and technological training, and to stimulate and co-ordinate research work of all kinds as an aid to post-war reconstruction. The sponsors of the motion were Mr. E. W. Salt, Lord Hinchingbrooke, Prof. A. V. Hill, Mr. M. P. Price, Sir George Schuster and Mr. H. Graham White. Most of the signatories to the motion were members of the Parliamentary and Scientific Committee.

The exact terms of the motion were as follows:

That this House, recognising that if the United Kingdom is to maintain its position in the post-war world and carry out effective plans for physical reconstruction and social betterment, research and the application of scientific knowledge in all fields must be promoted on a far bolder scale than in the period 1919-39, urges his Majesty's Government forthwith:

(1) To assure the universities that in planning future developments for research, teaching, and higher learning as a whole they will receive support from the State on a much larger scale than hitherto.

(2) To arrange that education and training in schools, technical colleges, and universities shall be directed at the earliest date towards providing a far greater number of persons highly trained in science and technology.

(3) To set in motion schemes to ensure a substantial and co-ordinated expansion of research activity by private firms, co-operative industrial research associations, and State and other research establishments; and to this end, to provide assistance by adjustment of

taxation, by more generous financial grants and through adequate priorities both in demobilization and for materials required for building and equipment.

Personal Notes

AT the invitation of the Government of India and with the consent of the Royal Society, PROFESSOR A. V. HILL, secretary to the Royal Society, is to visit India to advise on problems of scientific and industrial research in relation to reconstruction problems and the co-ordination of such research in India with that elsewhere.

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DR. B. A. KEEN, assistant director of Rothamsted, is joining the Middle East Supply Centre in Cairo, to which he will be attached for the next twelve months. He will be investigating the agricultural resources and their development in the Middle East, preparing a report on scientific and technical problems and making recommendations on the establishment of a suitable organisation to provide information and advice to benefit farmers of that region. He will be accompanied by DR. E. B. WORTHINGTON, director of the Wray Castle research laboratories of the British Empire Freshwater Biological Association.

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To advise on problems concerning fisheries, both marine and freshwater, in the Colonial Empire, the Secretary of State for the Colonies has appointed a committee which includes a number of scientists. Among them, is DR. S. KEMP, director of the Marine Biological Association of the U.K.; DR. E. B. WORTHINGTON, director of the Freshwater Biological Association; DR. E. S. RUSSELL, fisheries adviser to the Secretary of State for the Colonies; DR. G. A. REAY, director of the Torry Research Institute, Aberdeen; MR. J. R. NORMAN, deputy keeper of the Natural History Museum; DR. C. F. A. PANTIN, reader in invertebrate zoology at Cambridge University; and MR. R. S. WIMPENNY, naturalist of the Ministry of Agriculture and Fisheries.

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PROFESSOR NIELS BOHR, whose escape from Denmark was reported in the last issue of DISCOVERY, has arrived in England and is now living in London.

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DR. A. P. FLEMMING, Director of Research and Education at the Metropolitan-Vickers Electrical Co. Ltd., Manchester, has been elected President of the Institute of the Plastics Industry.

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DR. W. H. COATES, of the I.C.I. Ltd., is to be a member of the delegation visiting the U.S.A. to discuss post-war problems with the United States Chamber of Commerce.

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MR. F. RAYNS, Director of the Norfolk Agricultural Station and a well-known agricultural science expert, is to visit the U.S.A. under the auspices of the Ministry of Agriculture.

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SIR E. JOHN RUSSELL, who recently retired from the Directorship of the Rothamsted Experimental Station, is soon to visit Portugal on a lecture tour.

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DR. W. A. MACFARLANE has been appointed Director of Fuel Efficiency in the Ministry of Fuel and Power.

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LIEUT.-COL. W. B. R. KING has been appointed Woodwardian professor of geology at Cambridge in succession to Professor O. T. Jones, who has retired.

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SIR GEORGE THOMSON, professor of physics at the Imperial College of Science, London, has been appointed scientific adviser to the Air Ministry. He will be concerned with the examination of air operations from the scientific point of view, the methods, weapons and equipment used. On questions connected with radio-communication and radar apparatus he will be in consultation with Sir Robert Watson-Watt, scientific adviser on telecommunications. During the last war Thomson, who is the son of Sir J. J. Thomson, saw active service in the field as an officer in the Queens Regiment, but was later attached to the R.A.F. for experimental work and took part on a number of test flights to investigate aerodynamical problems. He visited America as a member of the British War Mission in 1918. The outcome of his war-time researches was the book "Applied Aerodynamics".

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SIR E. B. POULTON, F.R.S., the well-known zoologist, died at Oxford on November 20, at the age of 87. Until his retirement in 1933 he was Hope Professor of Zoology at Oxford University.

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The new Head of the Department of Mechanical Sciences, Professor J. F. Baker, Clare College, has a considerably increased programme of research work next term, and the inadequate facilities existing at present are to be augumented by the erection of a single bay, steel-framed building measuring 25 ft. by 80 ft.

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Royal Society Medals

THE ROYAL Medals for the current year have been awarded to Sir Harold Spencer Jones, the Astronomer-Royal, for his determination of the solar parallax and of other fundamental astronomical constants, and to DR. E. B. BAILEY, for his contributions to the knowledge of mountain structure and his studies on the tectonics of vulcanism. The following awards have also been made by the Royal Society:—

Copley Medal.—SIR JOSEPH BARCROFT, F.R.S., for his distinguished work on respiration and the respiratory function of the blood.

Davy Medal.—PROF. I. M. HEILBRON, F.R.S., for his many notable contributions to organic chemistry, especially to the chemistry of natural products of physiological importance.

Sylvester Medal.—PROFESSOR J. E. LITTLEWOOD, F.R.S., for his mathematical discoveries and supreme insight in the analytical theory of numbers.

Hughes Medal.—PROFESSOR M. L. E. OLIPHANT, F.R.S., for his distinguished work in nuclear physics and mastery of methods of generating and applying high potentials.

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Symons Gold Medal

The Council of the Royal Meteorological Society have awarded the Symons Gold Medal for 1944 to DR. C. W. B. NORMAND, M.A., D.Sc.

The medal is awarded biennially for distinguished work in connection with meteorological science. The medal for 1944 will be presented early next year.

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Duddell Medallist

The twentieth Duddell Medal has been awarded by the Council of the Physical Society to MR. JOHN GUILD, of the Light Department of the National Physical Laboratory, in recognition of his design of a number of optical and physical instruments of outstanding merit.

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Rubber Plants in Britain

AN account of the British experiments with "rubber" dandelions from Russia were given by Sir Geoffrey Evans, Economic Botanist to the Royal Botanic Gardens, at a press conference last month. He said that in connection with the rubber crisis Kew Gardens, at the request of the Ministry of Supply, undertook preliminary experiments with three kinds of rubber-producing plants from Russia—Kok-saghyz and Krim-saghyz, both species of *Taraxacum*, and Tau-saghyz, which is a salsify or *Tragopogon*. Test plots were laid down at Kew and at 22 other stations in England and Wales which had agreed to co-operate. The first year's results do not indicate that these plants are likely to prove capable of commercial cultivation on a large scale in this country. Tau-saghyz has failed everywhere. Krim-saghyz is rather delicate, and although it withstood last winter, which was very mild, it remains to be seen whether it will stand up to more normal winter conditions. Kok-saghyz is the most promising, but even here its suitability to British conditions is doubtful, while the amount of manual labour needed in its cultivation makes it an expensive crop to grow and harvest; at present it would be unwise to advocate any extensive cultivation. Analyses showed great variation in rubber content between individual plants, ranging from 2% to 17% in the dry root. The rubber so far obtained is of reasonably good quality, comparable to wild rubber from Africa.

Potato Crops from Dehydrated "Eyes"

SIR GEOFFREY EVANS also referred to the experiments made at Kew this year to test the possibility of raising potatoes from "eyes" instead of tubers. He said that by using only the "rose" end of the potato as seed it was possible to produce quite normal crops. These "chips" could be dried, after which they still retained their ability to sprout and grow into healthy plants; these dried chips weighed only one-fifteenth the weight of ordinary seed

potatoes. If the new method could be standardised it would result in great transport economies. The system seems to be specially applicable to the demands from the Colonies, where potato-production is greatly hampered during war-time by delay in sending seed potatoes by sea. By the new method it would be feasible to send the dried chips by air. The Ministry of Transport and the Ministry of Supply had been collaborating on this project and were sending some of the dried chips to our Mediterranean colonies this year. A detailed article on "Potato Eyes as Readily Transportable seed for the Colonies" by Sir Geoffrey Evans has appeared recently in *Nature*. (1943, **152**, p. 464).

Post-War Strawberries

THE East Malling Research Station, under contract with the Ministry and at the request of the Nuclear Fruit Stocks Sub-Committee of the Agricultural Improvement Council, has recently supervised the growing and distribution from a number of centres of over 900,000 strawberry runners to commercial growers. By the end of next season the figure is likely to reach 1,500,000 which will ensure for the fruit growers of Britain a nuclear stock of disease-free strawberry plants, so that first-class material will be available for planting after the war and for immediate use on such areas which are maintained under this crop during the war.

Geologists and the Post-War Era

THE Geological Survey of Great Britain has barely fifty professional geologists, and there is a like number on the Colonial Office Geological Survey lists. Post-war development of colonies and dependencies will call for a far larger employment of trained geologists, and that call is coming soon.

"Geology is bound up body and soul with the development of the mineral wealth of our land—that mineral wealth by means of which the enterprise of our people has placed our country at the head of the manufacturing and commercial powers of the world. Our science has not only the charge of the working out of all the detailed phenomena, subterranean and superficial, of the great coalfields and ironfields which lie at the foundation of our commercial supremacy as a nation, but it works out the characters and fixes the places of all the stony materials of which our cities and towns are built, our humblest dwellings constructed, and all our roads and railways are made. It deals with the sources and the quantities and characters of our water supplies, whether deep seated or superficial, the nature and distribution of our soils and indeed with everything which we derive from the ground on which we tread."

Among the great industries, only the oil companies have so far recognised that they cannot proceed without their own highly trained and experienced geologists, and they are already crying out for more to ensure development in the post-war world. A greater awareness of available geological knowledge would likewise increase the scope of employment of geologists in the coal, iron and other heavy industries.

Against these facts we have to record that the rate of intake of students to University geological departments, never large, has been falling persistently during the years between the wars, and the intensification of this shortage by a short-sighted "direction" to "scarcity subjects" during this war has already produced a serious post-war manpower problem.

Long Life without Sex

CULTURES of *Paramecium* are maintained in school and university laboratories all over the world, but one of the oldest must be that described by L. L. Woodruff (*Proc. U.S. Acad. Sci.*, **29**, 135, 1943). This particular culture, of the species *P. aurelia*, was started 1907 and so far 21,800 generations have been bred from the original specimens. But during the 36 years of its existence, no conjugation—the sexual process of this organism—has been observed, and it seems that the vitality of these unicellular (or non-cellular, to use the more modern expression) organisms does not suffer from the lack of conjugation. The rate of division in the culture, for instance, has remained more or less constant the whole time.

As zoology students know conjugation in *Paramecium* is not to be observed as frequently as their lecturers might wish. It is worthy of note that the completion of the film that Dr. H. R. Hewer of Imperial College of Science made about the life history of this organism was held up for this reason.

Russian Popular Science Magazine

AN interesting popular scientific magazine is now published in Moscow under the title *Nauka i Zhizn'* (Science and Life). Judging by the issue that has come to our notice, its interests range from astronomy and physics to medicine and geography. There is a discussion on aerodynamics explaining how an aeroplane is supported in the air, an article on the defensive mechanism of the human body against infection and illness, a comprehensive survey of radio direction finding methods including the Adcock system and pulse methods, a few remarks on the use of flooding in warfare, a historical survey of the expeditions to Cape Chelyuskin and several other articles. The articles are written by experts in an easy style with numerous illustrations and diagrams, and the use of mathematics is apparently avoided. An interesting feature is the section in which answers are given to readers queries, again covering a wide field. A calendar of memorable dates is also appended referring mainly to the events in Russian history. Taking into consideration present conditions the magazine is well produced. It is interesting to note that 35,000 copies are printed of each issue of this magazine.

Science by Cinema

SOME interesting details about the way in which the Chinese Government is utilising films to increase the people's knowledge, both general and scientific were given in a recent number of *Foreign Commerce Weekly*. In 1935, says the writer, the Chinese Ministry of Education requested provincial and municipal authorities to divide their territories into districts to serve as basic geographical units for the promotion of visual education. By 1937 slide projectors, film projectors (mostly for 16 mm. silent films) and generators had been sent to 135 of these districts. About one performance a week is given by the "celluloid circus" in each district. The Chinese Government has not restricted its attention to the showing of educational and industrial films; it is equally concerned with their *production*. Between July 1937 and December 1940 about 135 films were made by the three Government film studios which specialise, respectively, in news reels and educational films for the general public, films for the Army, and short films for distribution to schools. Films produced under Government-sponsorship are intended to fulfil at least one of the following purposes; teaching industrial techniques, imparting scientific knowledge, imparting general knowledge, supplementing school curricula and developing national consciousness. Typical films have shown the lives of great scholars, how to prevent malaria and the use of vegetable oils as petrol-substitutes.

Science in South America

IN the July number of *Ciencia*, the Mexican "Revista Hispano-americana de ciencias puras y aplicadas", which has just come to hand, Dr. José Zozoya reviews work which has been done during the last four years on the sulphonimides. This is followed by an important original contribution on the content in vitamin C of Mexican fruits by Giral and Viesca of the "Hormona" Laboratories. Marine algae of the North and North-west of Spain are reported upon by F. Miranda, who adds a useful bibliography of Spanish and French authorities to his article. The section of miscellaneous notes is interesting in that it gives the English reader a digest of the varied Scientific work going on in South America.

Christmas Lectures

THE One-Hundred and Fourteenth Course of six lectures adapted to a Juvenile Auditory will be given by E. N. da C. Andrade, D.Sc., Ph.D., F.R.S., M.R.I., Quain Professor of Physics in the University of London on Vibrations and Waves on Tuesdays, Thursdays and Saturdays, December 28, 30, and January 1, 4, 6, 8, at 3 o'clock.

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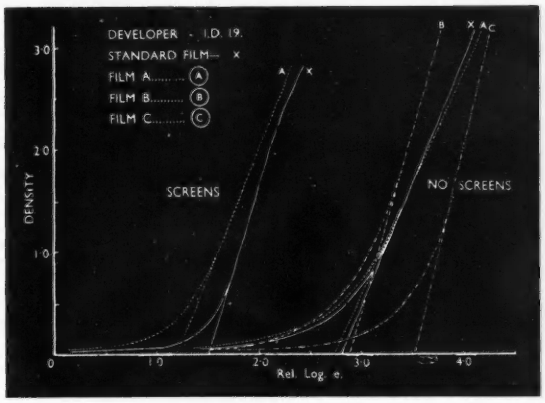

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ORDEAL BY FIRE

OUR forefathers used the ordeal by fire for two main purposes — a test of guilt and a test of endurance. The mediæval emperor, Charles the Fat, made his beautiful wife walk through fire clad in a waxed robe because he suspected her of infidelity. To-day the inhabitants of Great Britain in common with those of many other lands know what it is to endure the ordeal by fire from enemy air raiders. The British chemist is similarly concerned with fire in two main directions. First he is constantly examining new materials and processes for lessening the danger from fire. From the laboratories come chemicals impregnated with which wood; fabrics and even thatch are given powers to resist flames or are made proof against fire. Research is being pressed forward unremittingly to increase the fireproof properties of buildings by the development of fire-resisting paints, plasters and other building materials. War has enormously accelerated this work and great strides have been made by the British chemist to win the fire-battle of Britain by countering the effect of the incendiary bomb. There remains the test of endurance. Fire scientifically applied has the power to give metals the high temper and durability that modern conditions demand of them. Among the many important services that the chemist performs for the great metallurgical industries of Britain is the casehardening and heat treatment of steel. Nor does he only produce the chemicals used in the processes: he helps in the design and construction of the furnaces and other equipment in which the metal parts are treated. The British chemist is as active in defending the citizen from the dangers of fire as he is ready at all times to bend fire to the service of Industry.

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